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TRANSACTIONS
OF THE
AMERICAN INSTITUTE
OF
ELECTRICAL ENGINEERS.

REGULAR MEETING, NEW YORK, DECEMBER 21ST, 1892.

Micanite, and its Application to Armature Insulation,

BY EDWARD F. THOMPSON.

Catalogue of Members.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

NEW YORK CITY, December 21, 1892.

The Seventy-second meeting of the Institute was held this date, and in the absence of the President, was called to order by Vice-President Hammer, who acted as Chairman.

THE SECRETARY:—The next meeting of the Institute will be held on January 17th, when a paper will be read by Mr. Caryl D. Haskins of Lynn, Mass., on "Recording Electrical Meters."

At the meeting of Council, held this afternoon, the following Associate Members were elected:

Name.	Address.	Endorsed by
BLUME, JOHN C.	Assistant Electrician, American Telegraph and Telephone Co., 23 East 31st St., New York City.	F. A. Pickernell. Geo. A. Hamilton. Thos. D. Lockwood.
BOUGHAN, EDWARD L.	Supply Agent, American Telephone and Telegraph Co., 18 Cortlandt St., New York City.	F. A. Pickernell. T. D. Lockwood. Geo. A. Hamilton.
CARSON, DAVID I.	Sec'y and Gen. Supt., the Southern Bell Telephone and Telegraph Co., 18 Cortlandt St., N. Y. City.	F. A. Pickernell. G. A. Hamilton. Thos. D. Lockwood.
CREHORE, ALBERT CUSHING	Instructor in Physics, Cornell University, 117 East Buffalo St., Ithaca, N. Y.	Edw. L. Nichols. Ernest Merritt. Harris J. Ryan.
DUNBAR, F. W.	Assistant Electrician, American Telephone and Telegraph Co., 153 Cedar St., New York City.	G. A. Hamilton. F. A. Pickernell. Thos. D. Lockwood.
MAURO, PHILIP	Counsellor-at-Law in Patent Causes, (Pollock & Mauro), 620 F. St., Washington, D. C.	F. L. Freeman. E. Berliner. Thos. D. Lockwood.
MORROW, JOHN THOMAS	Electrical Engineer, General Electric Co., Lynn, Mass.	Elihu Thomson. E. W. Rice, Jr. H. F. Parshall.
PARKHURST, LIEUT. CHARLES D.	Inspector, Watervliet Arsenal, West Troy, N. Y.	Louis Duncan. E. G. Bernard. Geo. O. Squier

Total, 8.

At the meeting of Council, held in Chicago, June 7th, the following Associate Members were elected.

BUBERT, J. F.	Electrical Engineer, The Mather Electric Co., 116 Bedford St., Boston, Mass.	W. A. Anthony. John Waring. W. H. Powell.
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796 ASSOCIATE MEMBERS ELECTED AND TRANSFERRED.

CLAFLIN, ADAMS D.	General Manager, The Mather Electric Co., 116 Bedford St., Boston, Mass.	W. A. Anthony. John Waring. W. H. Powell.
FORD, WM. S.	Assistant to Chief Engineer, The American Bell Telephone Co., Room 73, 125 Milk St., Boston, Mass.	T. D. Lockwood. I. H. Farnham. J. J. Carty.
SHAIN, CHARLES D.	District Manager, Edison General Electric Co., 44 Broad St., Box 3067, New York City.	Geo. M. Phelps. T. C. Martin. Jos. Wetzler.
THOMAS, BENJAMIN F.	Professor of Physics, Ohio State University, Columbus, O.	R. W. Pope. T. C. Martin. Jos. Wetzler.
WELLS, DOUGLAS	Sup't of Telegraphs, and Engineer to Government, Nassau, Bahamas.	Herbert L. Webb. G. A. Hamilton. R. W. Pope.
Total, 6.		

The following Associate Members were transferred to full membership, their applications having been approved by the Board of Examiners.

MOLERA, E. J.	Civil Engineer, 40 California St., San Francisco, Cal.
WILSON, HARRY C.	Sup't. of P. O. Telegraph with the Government, Kingston, Jamaica, W. I.
CHANDLER, CHARLES F.	Professor of Chemistry, Columbia College, New York City.

REPORT OF MEETING OF BOARD OF EXAMINERS, DEC. 6TH, 1892.

Present—Messrs. W. B. Vansize, Chairman, E. T. Birdsall, G. A. Hamilton, C. O. Mailloux and E. P. Thompson. R. W. Pope, Secretary, present *ex officio*.

New applica- tions considered.	Applications reconsidered.	Approved and reported to Council.	Disapproved.	Laid over for further consideration.	Total considered.
	9	7	2		9
23		4	11	8	23
Totals, 23	9	11	13	8	32

THE CHAIRMAN:—[Vice President Hammer.] Probably you all have noticed little slips of paper on the seats and wondered what they referred to. The Council has, for several years, endeavored to secure something in the way of a badge which would meet the approval of the members of the Institute. Various committees have been appointed and the most recent committee, of which I happen to be a member, has presented quite a variety of wax models and sketches and drawings of different badges, and at the Council meeting this afternoon one of these badges was presented, and I asked the permission of the Council to put these papers in the seats with a view of spreading this matter more fully among the members and bringing out the suggestions that they may have to make. There is a feeling

that we should adopt something in the way of a badge, especially in view of the approaching World's Fair and the meetings connected therewith. All the engineering societies, with the exception of ours, have special badges. The Committee has under consideration also, a certificate of membership. I have here a small badge made up according to the paper that you find in the seats, and after the meeting is over I shall be very pleased to show it to any of the members who desire to see it. It is a thing which we cannot discuss now, but the Council through the Secretary will be very glad to receive any suggestions from any of the members as to improvements in this design, or criticisms upon it in any way. All that we wish to do is to secure the best thing and something that is endorsed by a majority of the members. I might say that the little sketch on the blackboard, which is, however, very crude, gives a slight idea of it. After the meeting is over, the badge, made up exactly as it is represented, can be seen.

We will now have the pleasure of listening to a paper entitled "Micanite, and Its Application to Armature Insulation," by Mr. Edward P. Thompson, Member, for Messrs. C. W. Jefferson and A. H. S. Dyer.

The following paper was then read by Mr. Jefferson :

*A paper read at the seventy-second meeting of the
American Institute of Electrical Engineers,
New York, December 21st, 1892. Vice-President
Hammer in the chair.*

MICANITE, AND ITS APPLICATION TO ARMATURE INSULATION.

BY EDWARD P. THOMPSON, M. E., FOR CHARLES W. JEFFERSON AND
ARTHUR H. S. DYER.

An armature and its commutator consist of the combination of two elements; namely, electric and magnetic conductors and insulators. In the earlier days of armatures, the electrical and mechanical dimensions and proportions of the conductors were considered of prime importance. The first armatures were small and the electromotive force low, and consequently little attention, comparatively, was given to the element, insulation. Lately, simply paper, cloth, convolutions of ligatures, or these materials impregnated with shellac or similar insulating varnish or paint, were employed for the purpose of preventing leakage or short-circuit. To remove the solvent of the shellac, the armatures were baked for twenty-four hours. Judging from the variety of materials used at present, and the changes from one material to another, it would seem that the insulators are now receiving their share of consideration, while the core, wires, commutator-sections and other conducting portions are secondary details. Why so much difficulty with armature insulators and so little with other insulators, such as line insulators? Because, in the former, not only must the material be of extremely high resistance, but also unaltered under the effects of heat, and must be crowded into very small quarters. Space must be economized. If the electric current or heat alone were present, and if space were not so much limited, the problem would be easily solved. It yet remains to be proved that any known substance is abso-

lutely a non-conductor—nor is the resistance of a given conductor constant. Unfortunately for the armature constructor, the worse the conductor, the less the resistance with increase of temperature. An extra current is produced in metals upon variations of current. A diminishing of current occurs when first entering a substance of high resistance. Finally, and gradually the current becomes constant. This action for convenience is often called polarization. As this property is noticeable only in long lengths of the insulating material, it has little bearing upon any of the armature elements other than in connection with the covering of the wires. The substance possessing the property of polarization in a marked degree is gutta-percha.

Paper or fabrics by themselves, should never be used as an insulator, because when moist they conduct a current so well that they may properly be termed semi-conductors. A coating of shellac or oil upon almost any substance enormously increases its resistance, and protects porous and deliquescent substances from water. Paper thus covered, serves with machines of low electromotive force, the purpose of preventing leakage, but, by no means perfectly in practice, with large machines. Its advantages are more in the nature of convenience and cheapness than of efficiency.

Paper which has been thoroughly dried is of very much higher resistance—so high that it falls under the head of non-conductors, and therefore, the shellacs should not be applied until after the paper has been subjected to a thorough drying process.

It is a peculiar property that a given substance in a compact condition is of very marked higher resistance than when powdered or comminuted; for example, pulverized glass is a semi-conductor, while sheet glass is as high in resistance as silk. This property has been noticeable in armature practice. If the insulating material is cracked here and there, it is unfit for armature use. The cracks are in the nature of interstices between the particles of a powder, and at the cracks the material is in part ground. The explanation may lie in the distinction that the pulverized material has more surface, or that damp air exists in the spaces between the particles, or that a spark can traverse a gas better than a solid, or that each particle becomes coated with a film of moisture. The last seems the most probable, because the best surface concentrators of water usually exhibit the property most strongly.

The locations of insulation in an armature are between the armature disks to prevent eddy and Foucault currents; between the core and the windings to prevent the current from short-circuiting the coils through the core and burning out the armature; between the commutator-sections to prevent leakage from one coil to another; over projections or in grooves in the core; and around the wire to guide the current in convolutions. All these parts, even in the best made armatures become more or less abnormally hot. Means have been planned and sometimes put into practice for cooling the parts, and thereby saving the insulation. One method consists in constructing the armature after the style of a fan or with large radiating surface; another, in equipping a device to blow out the sparks at the commutator, and again, in using cooling insulating liquids. With whatever precautionary means the machine is equipped, the parts, either accidentally or through inefficiency of means, will become abnormally hot. The machine will be injured if combustible materials form the bulk of the insulator. The materials of an ideal armature consist of copper, iron, and a heat-proof and water-proof non-conductor. If the material is combustible, or altered in its chemical nature, by heat, its resistance is changed and generally lowered. Manufacturers of incandescent lamp filaments know that complete carbonization cannot take place except at a very high temperature, like 3000 degrees Fahrenheit. An armature may rise to 500 degrees. At this temperature, easily carbonizable materials, such as linen, cotton and other forms of cellulose are weakened, blackened and the resistance reduced. Shellac, although blackened at this temperature, is converted into those compounds whose resistance is not lowered. Shellac forms an exception therefore, in being charred by such a temperature without reduction of resistance.

There is a greater detriment than chemical change by heat. The material cracks, becomes somewhat comminuted, and the resistances, both mechanical and electrical are therefore greatly reduced. If paper or cloth, or even shellac is depended upon as the insulating material rather than as the binding material, it is not electricity proof; because principally, it becomes, when charred fractured at numerous points, if not completely pulverized. As to why shellac is not appreciably lowered in resistance by partial carbonization may be because it is an animal substance.

One of the most important attributes of an armature should be its rigidity. It should be like a rock in this particular. If the

insulation should consist of a soluble material, for example, and the same dissolved out after the completion of the armature; or of some material that would be reduced in size by heat; then the wire and bolts would soon become loose from the rapid rotation and vibration, and finally the armature would be useless. Change in volume of the insulators has caused nine-tenths of the armature break-downs.

In the matter of insulation between the disks it was found that oxidized or rusted laminated armature disks would insulate without any addition of paper or similar insulating films. The only difficulty with such a construction is one of degree. Iron rust insulates, and it is heat-proof; but it does not insulate sufficiently to compensate in most instances for its simplicity and cheapness, and besides it is not applicable to any other part of the armature than between the laminae of the core. The great advantage lies in the extreme thinness of the oxide coating, whereby a large amount of iron is obtained in the core. A modification has been suggested, which consists in placing thin mica sheets between every half-dozen of the disks. Again, iron wire, or ribbon rusted has been employed for armature cores. The wire or ribbon is formed into a ring, around which is the electric conductor. Another modification consists in case-hardening the iron, and also in japanning the surface. As to commutator insulation, natural mica sheets have been almost universally employed.

If it were not for the matter of mechanical construction and heat, glass would make a good armature insulator. It could be molded into any form and made of any degree of thinness. Its objections, however, are well known. Very gradually, and more so than would be conjectured, mica made its appearance in armatures. The introduction of mica into practice appears to have been brought about in the following manner:—An accident would happen to an armature, and before the next night it must needs be repaired. In order to make the temporary remedy, mica sheets or bars would be interposed. In the case of subsequent accidents, the portion repaired by mica was the last to yield. Therefore it was proposed to build the armature primarily with mica. But this change took place very, very gradually, but surely. Manufacturers of stoves, the leading houses being also importers of mica, soon experienced a growth in the mica department of their business, until at present some import more for the electrical industry, especially for armature use, than for

stoves. Why it was not employed from the first, no one could positively assert, otherwise than to guess that no one probably thought of it, or insulation was not considered of much comparative importance, or cheapness of material in construction was allowed to counterbalance efficiency of action and durability.

Of all substances, mica probably is the best material for use in armatures, if it is desired to obtain not only efficient electric insulation, but also durability under the influence of heat. The highest temperature to which an armature is subjected, even by short-circuit or bad construction, will have no injurious effect upon mica. Mica, thick or thin, may be held in a gas flame without cracking, burning or melting. It remains unaffected. The reason of this is better understood when it is remembered that it consists of aluminic silicate, containing also potassic, sodic and lithic silicates, and some ferrous and ferric and manganic oxides. Its chemical constitution varies.

One quality of mica is that which is commercially termed *amber mica*, and is usually mined in Canada. It is so named from its appearance and not because it is amber or in any other way similar to it than in its color. *India mica* is a commercial form noted for its uniform cleavage, extreme thinness of its laminae, flexibility without fracture and its resistance, which is much higher than that of amber. *Carolina mica* is another variety. It is obtained in sheets in the western part of North Carolina. It is the best mica for stoves, but it is too hard for some electrical purposes. Mica occurs in so many specific forms that particular names have been given to it.

Muscovite is one of the most common varieties. It occurs in different colors, namely, a dark green, yellow, brown, white and gray. This is the form usually found in small scales in granite, gneiss, and mica schist, and at the same time it occurs in larger, tougher sheets than any other form. A complete scale is irregularly hexagonal in shape. *Lepidolite*, or *lithia mica*, has a pearly lustre, as distinguished from the vitreous luster of *muscovite*. Its scales are usually very small, and it is found in limited varieties of granite and gneiss. *Cryopholite* is a subvariety of *lepidolite*. A characteristic feature of the form *meionite* consists in its occurring much cracked within. It has been found in geodes. *Biotite* is a form found in volcanic rocks in small scales. It contains much iron and magnesia compounds. *Phlogopite* occurs usually in limestone. Its subvarieties are *aspidolite* and *mangan-*

ophyllite. A very brittle variety is lepidomelane. It is also practically opaque. Its subvariety is astrophyllite.

The insulating power of mica is superior to that of any other substance applicable to armatures. An advantage, peculiar to itself, is its even, laminated structure. How wonderful is the thinness of its individual layers! A piece of ordinary writing paper is about .005 inch. Mica layers have been obtained of a thinness of .00013 inch. Mechanical difficulties prevent its being split thinner. By pasting it upon a hard surface and splitting it off as much as possible, the remaining fragments are so thin as to become beautifully iridescent. The builder of armatures can therefore split the sheets into any desired and uniform thickness with great ease and accuracy. An interesting property of mica and one not generally recognized, is its homogeneity of structure and clear transparency, although so black when thick. The writer used a piece one-quarter of an inch thick for observing the late solar eclipse. The effect was better than with smoked glass and as efficient as black glass much thicker.

A valuable property of mica in connection with commutator insulation is its proper degree of hardness, whereby it does not wear away too rapidly under the action of the brushes. If rubber were used, for example, even if it did not burn, yet it would wear off and sparking result, because the commutator surface would not be truly cylindrical. The brushes would be set into vibration. Again, mica is capable of the finest pulverization, so that any wearing which does take place does not result in the liberation of gritty particles, which would also cause sparking. Such mishaps occur with hardened artificial plastic insulators. The insulation should be just so thick that the current cannot jump across from one section to the other.

Although so superior for armature insulation, mica is, in its natural structure, accompanied by certain objections, which, in trying to overcome, were more serious than had been anticipated, as it was not until after a long series of trials that a successful article was produced, and not until a novel apparatus for cheapening the process of manufacture was devised. The apparatus is now in operation on a large scale. The description at present is confined, however, to the article, and to full information of its structure, manner of using and properties.

The objections alluded to are:—Mica, as found in nature, occurs in flat sheets only. It has a high degree of elasticity, so that

when once bent and released, it assumes its original form. If folded, its brittleness causes fracture. If the natural sheets are compressed in a mold, to try to form armature insulator heads for instance, it is completely broken up.

Secondly. Natural mica sheets correspond financially to plate glass. The larger the sheet, the higher the cost per square inch. Mica in small pieces, from four to six square inches, is exceed-



FIG. 1.—Micanite tube for insulating core projections.

ingly abundant and very cheap. It is often called waste mica, because very limited in its uses, and consisting often of trimmings from larger and more useful sheets. In medium and large sizes of armatures, the naturally built up mica is so expensive as to be objectionable, although not so much so as to entirely prevent its employment.

Thirdly. Between the hundreds, nay, thousands, of thin layers, damp air can enter, and also water, accidentally, which cannot easily or effectually be removed.

Fourthly. Mica splits so easily that handling causes injury.

Fifthly. Mica cannot be cut transversely to advantage. The edges are unworkmanlike, being ragged and jagged. Neatness in drilling, sawing and turning is difficult.

Among the attempts which have been made to overcome these



FIG. 2.—Micanite tube.

objections are those involving the use of pulverized or comminuted mica, which is mixed with a liquid cement and stirred into a paste. While still soft the mixture is rolled or compressed into any desired form, as if consisting of so much plaster-of-paris. In order to give it sufficient strength, one-third of the product is cement. The mica sparkles here and there on the surface, as it glitters on granite. This article should be called a cement insulator, and not a mica insulator, because the current can flow in a

straight circuit through the plate without encountering any mica. The cement forms numerous rectilinear paths for the current, independently of the mica; and therefore the product is in no sense an equivalent of mica.

A modification of this type of insulator consists of a coarse and thick textile fabric, whose pores and meshes are filled with a mixture composed of comminuted mica and a suitable adhesive substance. Another consists of finely divided asbestos mixed with pulverized mica, silicate of soda, and sulphur compounds. It is molded by pressure into any desired form.

The comminuted mica-cement type is useful in trolley wire supports and similar insulators, but for dynamos it is useless not only for the reason stated, but because of its softening and running under slight heat, being so necessarily rich in cement. If the cement is that kind that chars, the mica crumbles apart. Mineral powders have been mixed with it, to render it more fire-proof.

An example of the manner of using non-comminuted mica between the core and the windings consists in covering the core



FIG. 3.—Micanite armature slot insulator.

with paper, laying sheets of mica over the paper, then laying on another sheet of paper, fastening the whole together by convolutions of cord or similar ligatures, and finally applying the coils. During operation, the paper and mica may shift from their positions, and thereby affect the rigidity of the armature as a whole. Again, the process of applying the pieces, and keeping them temporarily in position, requires repeated efforts and results in a display of crude workmanship.

The exhibits before you show practical results of work carried on for the purpose of overcoming the objections named.

Large Plates.—One of these plates is a yard square and .035 inch thick. Another is of the same size and 1 in. thick, and another about 4 in. by 12 in. and 1 in. thick. They have nothing to do directly with the armature; but could serve as foundation plates for a dynamo or motor. They are practically all mica. A *natural* plate of mica of the larger size would be a curiosity—a rarity. Any of the sheets may be cut

up into any desired size and shape. The layers cling together much more tenaciously than in the natural plate. The path of least resistance from one side of the plate to the other is in a straight line, and a straight line intersects numerous mica sheets, and, therefore, the article is a mica insulator and not a cement insulator. These plates are made by such steps and apparatus



FIG. 4.—Micanite commutator-segment insulator.

that when subjected to heat in the armature, no injury whatever is produced.

Further, they are superior to a sheet of mica as it comes from the quarry, in that they do not absorb water or damp air; in that they are stronger to resist either pressure or tension; in that they may be neatly and easily sawed and drilled; in that they are enormously less costly; and in that they are of about the same resistance. By picking the exhibit apart, you can easily learn the structure. The mica of which it is composed is non-communited, but the pieces are exceedingly thin. The thickness is, by measurement, about .001 in., *i. e.*, about as thin as tissue



FIG. 5.—Complete drum-armature core protected with micanite.

paper. The sizes vary from 2, to 6 or 8 square inches. In each layer of mica, you may notice that the sheets overlap at their edges, and the cement between the layers is hardly noticeable. The former mentioned plate weighs about 4 lbs., and the latter over 100 lbs. It is a convenient quality in connection with mica that it can be split into pieces of the thickness re-

quired for the particular device under the process of construction. This property is also possessed by the plates exhibited. A thin and long knife may be caused to force its way in any of the many planes parallel to the surface, for the purpose of reducing the thickness or obtaining several thinner sheets from one thick plate.

Some tests were carried on to determine the relative values of these plates, and plates of comminuted mica and cement. Using the words of the electrician who originated and performed the tests, he says:—"For the purpose of insulating armatures, any solid insulating material should possess considerable strength and should maintain its strength when submitted to a moderate degree of heat. One piece tested consists of ground mica and shellac, mixed together and rolled or pressed between plates to a uniform thickness. In order to test it, I placed it upon a steam-table and left it for a minute, at the end of which period I tested its strength



FIG. 6.—Micanite ring for commutator.



FIG. 7.—Micanite washer.

by pressing the end of a piece of wire against its surface with very light pressure. The end of the wire, which was blunt and made of copper, easily pushed its way through the sheet and left a hole when removed. In removing the sheet from the steam-table it warped. The second plate consists of layers of sheets of mica, cemented together with overlapping joints. This sheet I placed on the same steam-table used for the other sheet, and after one minute had elapsed, tried to thrust the same piece of copper wire through the plate, but without success, though exerting all the strength that could be brought to bear upon it by my hand. After the sheet had been on the steam-table for five minutes, I placed it on a thick iron plate, laid a piece of the same copper wire upon its upper surface, put a second sheet of wrought-iron on top of it, and put the whole into a hydraulic press. It was then submitted to a pressure of 2,000 lbs. per square inch for one minute, and the result was the flattening of the wire and

a very slight crumpling of the mica sheet on the opposite side. The plate was then placed between two copper plates, and a weight of about four lbs. placed on the upper plate. The insulation resistance of the plate was then tested and found to be 25,500 megohms. I have used similar plates, similarly prepared, in motors, upon which a load of 50 h. p. has been placed, the entire thrust of the motor being received by the plates, which in this case were less than one-sixteenth of an inch thick. The temper-



FIG. 8.—W. P. armature core showing application of micanite slot insulators, and annular flanged micanite head.

ature was brought up to 650 degrees Fahrenheit, sufficient to burn cotton and melt hard solder without injuring the insulation."

Curved Specimens.—Similar remarks substantially, may be made about these, as about the large plates. Natural mica plates could never be given a permanent set, or molded into curved forms. The armature head consists essentially of an annular disk, provided with flanges around one or both peripheries. It is

in one sense a continuous piece. The flanges, you may notice, are not made separately and then fastened to the disks. There are no joints. Some of the peculiarly curved forms are furnished in order to illustrate that the article may be manufactured in any imaginable form of uniform structure, and in single pieces of uniform properties throughout.

Tubes.—In order to show the unlimited forms into which the material may be molded, a tube several feet long is exhibited. It may be cut up for use in certain types of armature, or when long, for use on board ship, and in general interior conduit installations in certain limited cases.

Stamped Forms.—The flat pieces of peculiar form could be made from the beginning in individual pieces, but are much more economically stamped from larger plates. Before using the large plates for any purpose where an exact thickness is required, they are burnished or surfaced off by machinery. Some of the plates before you, are in the crude state, and little scales here and there can be peeled off. The others are so different as to resemble a metallic surface, and when struck, ring like metal. Some of the forms are for large commutators. Others are flat rings for field-magnet cores. The very irregular flat pieces are for certain types of commutators. On account of the almost metallic qualities the product can appropriately be termed an "insulating metal." For convenience, it is called micanite.

Commutators.—In equipping a commutator with this material, it is necessary to know something which has been learned by early users, only through experience. The insulating and metal sections are put together in the usual manner, and the whole is heated to a temperature higher than that which it will reach in actual practice. While still hot, the elements are clamped tightly together.

Among the exhibits, is a mass of odd pieces of mica sometimes called waste mica; also, you will find similar pieces split as fine as possible. These are the result of the first operation. The next step consists in putting them together in the manner shown in the exhibits; that is, in layers with overlapping edges. Between them are layers of a cement having those qualities which fit the product for the purpose intended. Until only recently, these pieces were always laid on by hand. One girl could produce only one cubic foot per day. Now, one girl can do the work which formerly required twenty. The girl feeds the

machine, and it does the rest. The amount of cement employed is practically infinitesimal, because while in a plastic condition, the mass is subjected to such pressure that a mere trace remains, and yet sufficient to obtain proper adhesive qualities. From the beginning to the present, improved processes and new machinery have been required.

Dr. James Bowstead Williams has carried on a long series of tests upon the comparative specific resistance of mica and mica-nite. The data and results are as follows:

The conditions of the tests were absolutely the same in all cases. The potential was constant, being over 3,000 volts. A dynamometer served to maintain the same pressure for different materials. All the samples were kept at the same temperature and under the same hygroscopic conditions for several days. Samples were of uniform thickness. The best samples of mica-nite gave approximately the same reading as the best India mica, indicating that the resistance of mica-nite is equal to that of the best commercial mica.

I will close this paper by presenting certain topics which appear to be suitable for discussion, but which need not be adhered to. I hope you will discuss among yourselves as much as possible.

SUGGESTIVE TOPICS.

Armature.—Rigidity and its dependence upon insulating material employed. What has been learned by observation and special tests?

Preservation of Insulation.—Is it better to try to remove the cause of heating, or to neutralize the heat?

Burning Out Armatures.—What does insulation have to do with it, and what are the remedies? Also, what are the causes?

Durability of Insulation.—Differences in connection with armatures for inside use, such as installations and outside, *i. e.*, railway, mining and elevator use. Effects of atmosphere, motion and rough treatment.

Financial.—Does the expense of insulation, if the best, have an appreciable effect upon the cost of construction, and, on the other hand, will it pay in the end to put in a cheaper material?

Comparative Merits of Insulating Materials for Different Conditions.—Effects of high potential. Power to resist spark puncturing. What have tests shown as to properties of materials to withstand "break-downs," independently of high ohmic resistance?

DISCUSSION.

THE CHAIRMAN:—I am sure the members of the Institute have been much edified by the exceedingly interesting paper Mr. Thompson has presented to them this evening, and for my part I should like to see more papers of this practical character presented to the Institute together with exhibits such as Messrs. Jefferson and Dyer show here to-night.

Will Vice-President Hering please take the chair in order that I may open the discussion upon the paper?

[Vice-President Hering here took the chair.]

MR. HAMMER:—We see to-night what seems to be a most important advance in the art of armature insulation, which, while it may be new to many, has, I understand, been thoroughly tested, endorsed and adopted by the largest electrical company in this country.

Some who are here can doubtless date their experience in armature insulation back a dozen years or longer, and tell tales of experiments with mica, paper, ebonite, plaster-of-paris, of fields bored out to receive armatures intended for other machines, and more often armatures swollen by heat, moisture, or mechanical expansion until the chafing against the pole-pieces necessitated such a step; of coils burnt out and rewound, burst bands replaced; of dynamos which would not energize their fields because of low resistance, crosses in the armature circuit, of experience with high bars, soft bars, disconnected bars, short-circuited and grounded bars in the commutator, and other troubles too numerous to mention, many of which, by reason of increased knowledge and improved methods the electrical engineer to-day knows little of.

Mr. Thompson very truthfully remarks "that change of volume has caused nine-tenths of the armature break-downs." This change of volume has been mainly due to mechanical strains and heat.

Moisture by lowering the insulation between adjacent coils, framework and coils, commutator and shaft, etc., causes grounds and short-circuits followed by overload, charring and burning of insulation and disastrous results; besides this, the swelling of substances used upon the armature which absorb moisture create serious mechanical difficulties, such as bursting of wire bands, chafing against field magnets, putting armature out of balance, etc.

Insulating materials which absorb oil and moisture should never be used. Paper and vulcanized fibres have been largely used in armature construction, and are pretty fair mechanically, and while suitable in constructing the core, are unsuitable for commutator insulation, as are plaster-of-paris, asbestos, and such substances. Air-gaps are sometimes employed but necessitate constant cleaning to prevent the copper or other metallic dust from the brushes and commutator collecting between and short-circuiting the commutator bars.

Heat affects insulating substances by contracting, expanding, charring and burning, according to the degree of heat and character of materials employed, and in armatures heat is produced by the resistance in the armature windings, overload on machine, heavy grounds, short-circuits, hysteresis, Foucault or eddy currents in iron cores, armature windings, conductors and magnet pole-pieces, and by the use of commutator bars or brushes of insufficient size or imperfect contact between the same; and in armatures of both dynamos and motors, heat will to some extent always be present, and as it cannot be entirely eliminated and is often excessive under conditions of overload and accident, the neutralization of the heating effects by the employment of high-class materials is of vital importance.

Increasing the speed, involves increase of mechanical difficulties due to centrifugal force, which strains connections at commutator bars, lugs and radial bars, endangers the insulation of overlapping coils at ends of the armature, and strains the bands of piano or other wire enclosing the coils. Furthermore, there is the "drag" produced upon the armature coils by the magnetic field which is constantly varying, causing a strain, and a racking strain is produced by armatures being out of balance, a fault which is still sometimes met with. Besides all these difficulties, high speed increases the friction of rubbing surfaces, and the difficulty and expense in lubrication of the same.

From the foregoing it is self-evident that it is of paramount importance in armature construction that materials be employed possessing strength, rigidity, excellent qualities to resist heat and moisture, and to the highest degree insulators of electricity. These qualities, experience has shown us mica possesses perhaps to a greater degree than any substance known, and apparently the inventors of the process which has resulted in the remarkable samples we see here to-night, have by using "scrap mica" silenced the objections to its extensive use on account of its price, and by the methods of manufacture, enabling them to form this refractory material into almost any shape, have very greatly enlarged mica's sphere of usefulness and conferred a great benefit upon the electrical profession and the world at large. It would be interesting to know the specific inductive capacity and specific resistance of the micanite or combination of mica and shellac.

Fleming Jenkins gives the specific inductive capacity of mica as compared with air as 5, while that of gum lac or shellac is as low as 1.95.

Gordon and Silow give shellac a value as compared with air of 2.74. Mica not given.

Culley gives shellac fourth place in the list of materials of highest resistance and lowest conductivity, rating dry air first, ebonite second and paraffin third.

Munroe and Jamieson give the same rating excepting in case of certain kinds of glass, which they rank as second.

Ayrton and Perry give as the approximate specific resistance of shellac after several minutes' electrification as over 100 times that of mica.

Extension of alternate current practice, and use of high potentials, especially in power transmission work, gives a far greater importance to insulating substances, such as are here shown and they should meet with an extensive application.

Besides its application to dynamo and motor work, there are other fields of great importance, such as in the construction of alternate current transformers, this method admitting of the forming of the insulating substance for separating the high and low potential coils, insulating the core and encasing the high potential leading-in wires, and in the construction of direct current motor transformers, which I look to as developing a large field in this country, this material should find an extensive application in insulating the high and low potential wires in the armature.

In physical apparatus, such as induction coils of large power, the problem of insulation is of vital importance. It is interesting to observe that the largest two coils ever made in the world, the Apps or Spottiswood coil in England, and the Wallace coil of this country, have both been pierced, due to insufficient insulation at the high potentials employed, notwithstanding the great care in manufacture. I have here a photograph of the great Wallace coil, made by William Wallace of Ansonia, Conn., in 1869-70, which gave a spark 27" in length.

In the construction of powerful condensers, lightning arresters, switch-boards, instrument and machine bases, a field is open to the employment of such materials.

As an indication of the high tension which will ultimately be employed in power transmission and other work, and the necessity of high-class insulation, it is interesting to note that the Ferranti company in England is now supplying electricity for lighting purposes from the Deptford station at a potential delivered direct from the dynamos to the Ferranti mains at 10,000 volts.

These mains consist of concentric tubes of copper insulated by paper and run underground to sub-stations where step-down transformers are employed. The manager informed me that they had had considerable difficulty in keeping up the insulation in the armature. Each day the fields are slid apart and the armature carefully cleaned. The paper-insulated tubes apparently worked very well, but judging from the row of burned out transformers I saw being repaired, there is an excellent field for micanite in the high-tension transformer industry.

I understand that this material is produced very cheaply, and while in armature work we must consider mechanical and electrical perfection first, some comparative figures showing the cost of the material would be interesting and appropriate in this paper.

Mr. Thompson refers to the use of micanite in long tubes aboard ship and in general interior conduit installations. I should like to learn if it can be made cheaply enough in this form to fill such requirements.

The Chair will call upon Mr. Harold Binney to continue the discussion.

MR. THOMPSON:—Mr. Binney has sent a note saying that he is prevented from appearing this evening. He had some notes written out, but not in proper form to be read. He expected to come at the last minute, but the doctor would not let him on account of sickness.

As to interior insulation for shops and houses, a micanite tube, I suppose, would be used in the most important places, as through partitions, if too expensive to use generally. I simply mentioned that as a possible use of it. The principal object in bringing the tubes before the meeting was to show in what curious forms the substance could be produced, the tube being probably the most difficult one, natural mica being never known in a tubular form. In ships its cost would not prevent its use, because so superior to cheaper insulators. The *best* should be employed in ships, regardless of cost.

MR. CHAS. P. STEINMETZ:—We have listened to-night and at the last meeting to some very interesting statements regarding that quality which is called electrical resistance—not the resistance offered to the currents flowing in our electric circuits which we want as low as possible, but that resistance which hinders the escape of current from our circuits, which resistance we want as high as possible. That is, in other words, the insulation resistance. I have given the problem of electric insulation a good deal of attention also in the last year, and have made quite a number of tests which I hope to be able at a future meeting to report more fully.

My experience, however, has led me to an opinion somewhat different from that generally expressed. *I believe very little in insulation resistance.* It is a very nice thing indeed—on paper—to read that the insulation resistance of a machine is twenty or thirty megohms, or even higher. But, when you have determined the insulation resistance in the usual way, by the deflection of the galvanometer using a storage battery of say 100 volts, and then starting the machine, relying upon the “insulating resistance” of 30 megohms, it is not so nice upon breaking the circuit for the first time to see the inductive discharge from the series field break clear through your 30 megohms, reducing the insulating resistance to nil, and burning out the armature.

While, at the other hand, the insulation resistance of the machine may be suspiciously low, only a few hundred thousands of ohms, and still the machine may run continuously for years and years, under all conditions of load and overload, without breaking down, nay, getting better all the time, the more the insulating material dries by the heat developed in the machine.

What we want is, to insulate the electric circuits of the machine so that the machine will stand and work without breakdown under all conditions of usage; and as long as air, which is the *poorest* insulation, that is which breaks down easiest, has an *infinite* electric resistance, while just the *best* insulating materials—best in “disruptive strength,” that is standing electric stresses without giving way—as mica, have a comparatively *low* electric resistance, the insulating resistance gives us no indication as to the reliability of the insulation of the machine. To see this more plainly, let us examine the behavior of different insulating materials.

Take, for instance, two plates, put them against each other at a distance of, say, one-tenth of a millimeter, that is .004 of an inch of air between them. Now, measure the resistance at say 100 volts difference of potential between the plates. It is infinitely high. For I do not think anybody ever measured the true resistance of air and found any other result than infinite. Now, raise the potential difference between the plates to 500 volts. A spark will pass across the gap and this insulating resistance which a moment before was infinite, is now reduced to nil; it has broken down. Now, replace the air-gap by a piece of dry fibre of the same thickness, and measure again the insulating resistance in the usual way. You will find the resistance measurable, hence infinitely smaller than the resistance of your air-gap. Still you may raise the potential to 500 or to 1,000 volts, and the fibre will stand the pressure. It will break down under a stress of about 1,300 volts. Now, replace the fibre sheet with a sheet of mica. The resistance is very much smaller than the resistance of the fibre, to say nothing of the air. But you may raise the difference of potential at the terminals to 10,000 or 20,000 volts and the mica sheet will stand. The electricity will rush out from the terminal plates upon the mica sheet in long, glowing streamers, beating against the mica with a hissing noise, and forming a broad, electrostatic aurora of violet light, and still the mica will not break down. This is the property we want, but this disruptive strength has nothing to do with insulating resistance. On the contrary, those insulating materials which have the highest resistance, like air, just happen to have the lowest disruptive strength, while those materials which are relatively inferior in insulating resistance, like mica, stand electric stress best. I have never found another material which will stand such enormous electrostatic stress, for the same thickness, as mica will stand, and still its electric resistance is comparatively low. The consequence, therefore, is, if we insulate a machine or any other apparatus, the measured insulating resistance will say nothing to us about the disruptive strength of the machine. There may be, perhaps, two bare wires almost touching each other, with a thin film of air between; a galvanometer test will show a resistance of heaven knows how many megohms, and still the machine will break

down instantly, while you may insulate this whole machine with, say, ordinary fibre or mica and you will find—if the fibre is a little damp—perhaps only a few hundred thousands of ohms resistance; still the longer the machine runs, the higher its resistance becomes, and the better the machine gets, and it will not break down. So a very high insulating resistance is not a measure of the reliability of the machine against breakdowns. If we consider it from this point of view, we may learn something even from the civil engineer, though we generally boast—properly—that we are much far the advanced in exactness of methods. When the civil engineer wants to build a bridge for instance he does not measure the elongation of a test piece of the iron to be used by a micrometer, but he loads it until it breaks, and then determines the breaking strain, and thereupon bases his calculations. That is what we want to do also—to expose our material to an electrostatic stress until it breaks down, and judge it thereby, but not by its specific electric resistance. For even if the specific resistance is very low—comparatively—the current which may leak through the insulation is by far too small to do any harm. Resistance tests of the machine insulation are of a relative value in so far only, as they may give us a clue as to whether there is a weak spot somewhere in the insulation, but not necessarily so.

They will not show how safe the machine is. But it will show if we connect the copper part to one terminal and the iron part to the other terminal of a circuit carrying a potential of 3,000 volts and then see the machine not broken down. The megohms might be all right—the fire underwriters occasionally require them. But otherwise it is safer to test by applying a higher potential than the machine has to carry. Because if an insulation stands a potential of 3,000 volts we are sure it will stand a potential of 500 volts. But then there are other points to consider in insulation—the mechanical behavior of insulating materials. While mica has enormous strength against breakdowns, the least kink in a mica sheet, the least bend, will reduce the strength enormously, and while a single sheet of mica will stand enormous potential, simply bend it over a couple of times—you hardly see any kink—still it breaks down at a much smaller potential. But still it is very much better than air or even dry fibre.

Furthermore, you have to consider how the insulating material behaves not only against heat but against electric arcing, because in many cases, for instance at the commutator or the breaking-switch you want insulating material which is fire-proof, and keeps up its insulating qualities against the electric arc. All organic compounds are not fire-proof and consequently not fit for places where the electric arc strikes. Take any one of these mixed compounds, even micanite, put it between the discharge plates and raise the potential difference until a spark, followed

by the arc, strikes across—it is set on fire. Micanite may stand the heat of the armature all right where the spark does not touch it. The temperature may rise several hundreds of degrees, so that the micanite gets black, the cement is charred, and it will continue to insulate, but still the arc will set it on fire. While if you take a sheet of genuine mica and let the arc strike across, along the edges of the mica sheet, the arc simply melts the mica down farther and farther, but it cannot set it on fire. Most of the other organic compounds are very much worse indeed, because they are set on fire by the least arc, some even with a kind of explosion. This is another point to be considered.

Hence we must make up our minds that there is no insulating material which is fit for every purpose; that each insulating material has its special application; what is very good for one case is not good for another. So for places, where arcing is to be expected, as on commutators or switches, I do not think that we can ever get anything better than genuine mica, or asbestos paper, or soap-stone, porcelain, or any other mineral compound. In all places, where not exposed to arcing, mixed organic compounds will be very good. The disruptive charge will not pass through micanite at even more than moderate potential. It is not as strong as genuine mica—perhaps not more than one-half or one-quarter as strong, but even then far superior to any other similar material. In other cases ordinary dry fibre is a very good insulating material. It has come into discredit more than it deserves, because it gets damp, and when it gets damp, it no longer insulates, but in places where it cannot get damp, especially where it is kept slightly warm, it is a very reliable material and has a much higher value than is very often supposed. Again, where very high insulating resistance is required, as in electrostatic apparatus, there is paraffin and hard rubber, which surpass, I believe, all materials except air. So we have to find out which insulating material is the best for a particular use; there is no insulating material which is good for every purpose.

MR. A. E. KENNELLY:—I would like to say, in reference to the subject last mentioned, that the value of a material like micanite does not seem to lie wholly in its insulating capabilities, but rather in the fact that enables us to employ in it a substance with say one-fourth of the resistance to electrostatic rupture that true mica has, at a far lesser cost; and it is surely better to have something which has a quarter of that capability and which is within your commercial means than to know that a substance exists having the full capability, but which is so precious that you cannot use it at all. I think the paper is an interesting one, because it gives us a number of details which can only be gained by experience.

In regard to mixtures, I should think that any material which contained silicate of soda would be a suspicious one, for silicate of soda is not an insulator. It is, of course, a high resistance material but it conducts quite appreciably.

PROF. W. A. ANTHONY:—I am very much interested indeed in this material, and the company for which I have been working for the last few years has been making some use of it in the construction of machines, and have found it a very excellent material in a great many places. I agree with Mr. Steinmetz that the measurement of the insulating power of the material is no test of its value in the machine. The effect of this high insulation, of course is good. But the important fact is, that it will stand a great deal of mechanical wear and tear, and a very high temperature without breaking down in insulation; and you may even have something of a short-circuit without burning through it, while almost any of the other insulating materials are at once burnt out and destroyed by any short-circuiting. It seems to me that this is one very great step in advance, in the structure of insulating materials, enabling us to use what is practically as perfect an insulator as mica, and obtaining it in just such forms as we want it. I confess that I was very much surprised when I first saw the great variety of forms in which it could be made.

MR. CARL HERING:—I would like to ask a question about the tubes made of this material. I notice that they have lap and butt joints, and they are apparently not made of a continuous sheet. Will such a joint stand well; is it not apt to open?

MR. CHAS. W. JEFFERSON:—This tube [indicating,] for instance, is made from a thin sheet rolled out. The sheet was about five feet long; so, really, it is not a butt joint. *These* [indicating] are not made from a large sheet, but they have an over-lapping joint of about an inch or an inch and a-half, and it is the same with all these. But the tubes we make from thin sheets or thin strips have quite a considerable length.

MR. HERING:—I had reference to this particular tube [indicating] which seems to have a regular butt joint.

MR. JEFFERSON:—That large tube is made like this small tube. It may appear as if it was a butt joint; but it is not.

MR. RALPH W. POPE:—It appears to me that the remarks of Mr. Steinmetz on this question are a very fine illustration of the difference between theory and practice. That is, we measure the insulation very carefully in the laboratory, and calculate that it is going to answer a certain purpose. It is then introduced in practice, and we learn by experience that not merely insulation resistance, but other qualifications are required, showing, as he says, that different insulations are adapted for different conditions.

My object in rising was to call attention to a reference in the paper which has been corrected once, but the error has been so widely circulated that it seems almost impossible to eradicate it. The paper says on page 800:—"All these parts, even in the best "made armatures become more or less abnormally hot. Means "have been planned and sometimes put into practice for cooling "the parts, and thereby saving the insulation. One method con-

"sists in constructing the armature after the style of a fan, or with
"large radiating surface; another in equipping a device to blow
"out the sparks at the commutator."

This blowing out of the sparks is the point to which I refer, for the reason that Prof. Thomson, at the meeting held in May, 1891, in his discussion of the paper by M. E. Thompson, on "An open coil arc dynamo," spoke as follows:

"I called Mr. Thompson's attention to his statements in regard
"to the blowing out of the sparks as expressing an erroneous
"idea in relation to the machine. This erroneous idea he will
"find expressed in Prof. Silvanus P. Thomson's 'Dynamo-electric
"Machinery' that the air-blast in the Thomson-Houston three coil
"machine is for the purpose of blowing out the spark. That is
"not at all the case; it never was the case; and the air-blast was
"introduced for no other purpose than to make it possible to
"run the machine steadily at high differences of potential with a
"commutator that could be freely oiled."

This is on page 389 of vol. viii. of the TRANSACTIONS. As this error is creeping into dictionaries, and other works which are supposed to be standard, we should all take pains to correct it wherever possible.

PROFESSOR FRANCIS B. CROCKER:—I think that what Mr. Steinmetz said about tests of insulation at different voltages is the key-note of the problem. But I think he went a little too far in saying that the usual test of insulation showed nothing or showed next to nothing. It seems to me that although a test of insulation resistance is not conclusive, I would much prefer to run a dynamo or a system of conductors, or any other electrical apparatus or system, when it showed 100 megohms insulation than when it showed 100,000 ohms insulation. In fact if it showed 100,000 ohms insulation, I should be afraid to start up. If it showed 100 megohms I should have considerable confidence that it would run all right. It seems to me that the best way to do, is to test the insulation at the voltage at which you intend to work. That covers both points. You test the insulation, which has been the customary thing to do for some decades now, and you also subject it to a potential, or power to break down, which Mr. Steinmetz rightly considers very important. There is no objection to it except the practical difficulty of getting a potential of whatever is necessary—one or two thousand volts, or whatever it may be. But Mr. Williams showed us at the last meeting an electrostatic method of doing that, and for some months past I have been making tests of insulating materials, at several thousand volts with a direct current dynamo machine, without any difficulty whatever. We pass the current from the dynamo machine through the given insulation and a galvanometer according to the ordinary direct deflection method well known to all of us, and observe the insulation resistance—the old-fashioned insulation resistance which Mr. Steinmetz thinks

amounts to nothing—and at the same time we test the power to withstand disruptive discharge. It seems to me that that kills two birds with one stone. We get a quantitative result and also a test of the power to withstand the stress, and that stress of a potential which is applied to actually break down an insulator is very similar to a mechanical stress. It is a good deal the same kind of a stress as a point would exert resting on the centre of a pane of glass—at a certain pressure it will break through. That, of course, is simply an analogy, but it is quite close.

In testing the disruptive resistance or the breaking strain, Mr. Steinmetz said very truly that we ought to put it on the same basis as all other engineering problems, and that is to make an actual breaking strain test. In mechanical or civil engineering we simply take a test piece and subject it to a breaking test. Now, we can do the same in electrical engineering, and I think it should be the custom—I know it has in the practical work that I have been engaged in—to subject machines intended for 500 volts strain, to, 1,500 volts test pressure. That is no more than is proper. It is simply a factor of safety of 3. If you raise the factor of safety to 5, so much the better. Electrical engineers should have their factor of safety, and should consider it part of their work just as much as civil or mechanical engineers.

A dynamo machine or electrostatic machine can easily be obtained which will give any reasonable voltage, from one to five thousand. I have a small machine that gives 5,500 and will run all day long at 5,000 volts. Such machines can easily be obtained. Why not subject any insulation to such a test, and at the same time pass the current through some galvanometer or other device to show quantitatively the insulation resistance at the same time that we test its power to withstand the potential? In regard to the galvanometer, I will point out one difficulty due to electrostatic disturbance, that is, the needle of a galvanometer connected to a dynamo or electrostatic machine, giving 5,000 volts, or anything approximating that, will be acted upon just the same as a pith ball in the vicinity of an electrostatic machine—it will fly around and you will get a false deflection. That is quite confusing sometimes and very difficult to eliminate. The proper way to overcome this seems to be either to ground the terminal of the source connected to the galvanometer so as to reduce the potential to zero, or else to make the potential of the coils equal to that of the needle by connecting the needle to the coils by a little wire passing down into a bath of sulphuric acid, or something of that sort. The electrostatic disturbance will be much greater than the current-effects, in a great many cases. Mr. Williams uses purely electrostatic means—an electrometer—and observes how long it takes to discharge at a given charge. But it seems to me that purely electrostatic strain is not so severe on a given insulator as the current from a dynamo machine. I think that 5,000 volts applied from a dynamo machine is a more severe test than 5,000 volts applied

from an electrostatic source. There is some power behind in one case, and nothing behind in the other. That sounds a little absurd. But I think there is something there that we are not quite familiar with. So far as my experience goes, a potential applied with the backing of a dynamo machine, so to speak, is a more severe test than a simple electrostatic potential without any dynamo.

THE CHAIRMAN:—It seems to me that the remarks of Professor Crocker upon backing up the insulation tests with the current from the dynamo and the remarks which Mr. Kennelly made relative to the using of this material and its advantage over mica and other expensive substances, *i. e.*, that it can be not only formed, but that it has the great advantage of being considerably less in cost are very pertinent and I think from the remarks of Professor Anthony and of others here and from statements made to me by the gentlemen who presented these samples to-night, that this material is not in an altogether experimental stage, that it has been worked commercially and on a considerable scale for a number of years. I would like to ask Mr. Thompson if he can give us a little information as to the relative cost of this material, taking any particular size or sizes, as compared with mica.

MR. THOMPSON:—Mr. Brooks or Mr. Kingsley, I think, would be better able to give figures on that. They are posted on the business points better than I am.

MR. LEWIS W. KINGSLEY:—I would state that on sizes, say 6 by 8, the cost would be one-half that of mica. In very small sizes it costs more than small mica, but with large sizes it costs one-half, and you can get, of course, any size much larger than you can obtain it from the mine.

MR. STEINMETZ:—I do not want to be misunderstood with regard to my opinion about insulating resistance. I do not mean to say that insulating resistance is of no value whatever. It has some value. It shows whether everything may be all right or whether something may be wrong. We are all familiar with the insulating resistance of materials, and know about what resistance we have to expect, and where we find exceedingly low insulating resistance we must suspect something is wrong. Very often we find that the insulating resistance becomes all right by a couple of hours sojourn in the steam box, especially where fibre or asbestos paper was used. Hence the low insulating resistance is a good hint to look things up and see whether everything is all right. But it is no reliable test of the safety of the machine.

Then with regard to exposing all the materials to a break-down test, that is what we have done for several years, and found it very reliable. But if we want to combine it with the resistance tests, then the only safe way would be to make the tests at a potential considerably higher than the normal, because as long as we have inductances in our circuit we cannot avoid occasionally a sudden rise of potential beyond the normal value, as in break-

ing circuits, etc., and we have to take this in account because this insulating resistance especially of air does not vary as a continuous function of the potential, but is infinite up to a certain point, and then suddenly drops to zero, practically. So we have to make the insulating tests considerably above the normal potential.

I am glad to see Professor Crocker propose the same factor of safety as we have used a long time, testing 500 volt machinery by 2,000 volts.

But with regard to the source of these testing potentials, I do not think we need to bother much about continuous current dynamos. For what purpose do we have the alternating current transformer? From ordinary 50 volt mains we can obtain any potential difference, of 2,000 volts just as well as of 3 000 volts, and I even think the alternating potential test is more reliable, because alternating stress is more severe than continuous electrostatic stress. Lately I looked up the literature for tests about disruptive discharges through the air and found quite a disagreement of that kind, so that I am almost inclined to believe that the disruptive strength of air is less with alternating potentials and decreases with increasing frequency. So if we use a frequency of 150 periods and 2,000 volts, we are sure the insulation will break down if it is liable to break down. *Power* indeed must be behind the *potential*.

With regard to micanite I can only say that I found it very reliable—superior to all the other insulating materials except genuine mica, but it is not absolutely fire-proof, so that I prefer to keep it away from the arc.

THE CHAIRMAN :—I think the gentlemen of the Institute will agree with me that we know a great deal more about mica to-night than we ever did before, owing to Mr. Thompson's admirable paper and the discussion which followed its reading. If there are no further remarks I will call upon Mr. Thompson, if he desires to say anything on the points discussed by the gentlemen present.

MR. THOMPSON :—I will not take time to say anything further. I think I have had my say in the paper. But Mr. Jefferson probably may have some further practical experiences to disclose.

MR. JEFFERSON :—I would like simply to state that a great number of armatures have been insulated with this material and have always been tested on 3,000 volts alternating, with what they call a transformer up to 10,000 volts. We had a great number of armatures that would stand that potential with this micanite with a resistance of 190 megohms which is as high as we have, all the way from 190 down to 50 megohms.

THE CHAIRMAN :—Have any mechanical tests been made further than those referred to in the paper? There is a mechanical test referred to here in which the mica is placed under a great strain.

MR. JEFFERSON:—Yes, sir; the armature has been bound with a ribbon and the layers of the ribbon insulated with micanite and asbestos and then the current passed through the wire—sufficient to burn, almost melt the wire, and we found that the insulation has kept very well indeed.

THE CHAIRMAN:—Did it set fire to it?

MR. JEFFERSON:—No; there was nothing to set fire to. It did not blaze.

MR. THOMPSON:—I might add in regard to shellac or cement which was referred to, that those experienced with glue and its uses know that, in general, the less the cement and the greater the pressure, the better the adhesion. The amount of cement in these articles is almost infinitesimal. So it almost comes up to Mr. Steinmetz's standard about genuine mica being so superior. If the cement is so minute in quantity it is almost the same thing as mica.

THE CHAIRMAN:—If there are no further remarks, we will take pleasure in listening to Dr. Williams who is going to show us some interesting experiments in connection with these and other insulating materials.

DR. J. B. WILLIAMS:—There have been quite a number of specimens of different materials sent in that are claimed to be good for armature insulation, and I propose this evening to compare their resistance with that of pure mica by the electrostatic method. I will test them at a potential of nearly 4,000 volts. I will take the pure mica first. The thickness of this sheet which I am about to test is 45 mils. The disks between which it is placed—the equivalents of metallic disks—are about one-half inch in diameter. I will use just sufficient pressure to spread the buckskin-covered electrodes out firmly onto all portions of the surface of the tested material.

I would state that I believe there is a good deal in Professor Crocker's remark about having the power behind, and it is my intention in the near future to bring apparatus here before the Institute, and show the effects of alternating currents of one and two hundred thousand volts on different insulating material.

[Dr. Williams then went on with the tests, and when he had finished the meeting adjourned.]

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

CATALOGUE OF MEMBERS.

FEBRUARY 1ST, 1893.

HONORARY MEMBERS.

Name.	Address.	Date of Membership.
FARMER, PROF. MOSES G.	Electrician and Inventor, Eliot, Me.	{ A April 15, 1884 H. M. Oct. 21, '90
GREEN, DR. NORVIN	(<i>Past President</i>). Pres't Western Union Telegraph Co. P. O. Box 3393, 195 Broadway, New York.	{ A April 15, 1884 M Oct. 21, 1884 H. M. Dec. 3, 1889
KELVIN, <i>Lord</i>	LL.D., F. R. S. S. L. and E. The University, Glasgow, Scotland,	{ H. M. May 17, '92
PREECE, WM. H. F. R. S.	Electrician, General Post Office, London, Eng. Residence, Gothic Lodge, Wimbledon.	{ H. M. Oct. 21, 1884
Total, 4.		

MEMBERS.

ACHESON, EDW. G.	President, The Monongahela Electric Light Co., Monongahela City, Pa.	{ A Jan. 3, 1888 M May 1, 1888
AHEARN, T.	Ahearn & Soper, Electrical Supplies, Ottawa, Ont.	{ A July 12, 1887 M Sept. 6, 1887
ANTHONY, PROF. W. A.	(<i>Past President</i>). Consult'g Electrician. The Mather Electric Co., Manchester, Conn.	{ A Dec. 9, 1884 M Jan. 6, 1885
AYER, JAMES I.	General Manager, Municipal Electric L. & P. Co., 322 Pine St., St. Louis, Mo.	{ A May 19, 1891 M April 19, 1892
AYRES, BROWN	Professor of Physics and Electrical Engineering, Tulane University, New Orleans, La.	{ A Dec. 16, 1891 M Mar. 15, 1892
BARBERIE, E. T.	Electrician, 2021 Lexington Ave., New York City.	{ A Jan. 19, 1892 M Oct. 25, 1892
BATCHELOR, CHAS.	Electrical Engineer, 33 West Twenty-fifth St., New York.	{ A June 8, 1887 M July 12, 1887
BATES, J. H.	Vice President, Moore Electrical Manufacturing Co., 652 Hudson St., New York City.	{ A Sept. 6, 1887 M Oct. 1, 1889

MEMBERS.

Name.	Address.	Date of Membership.
BATES, MAURICE E.	Manager, Western Electric Construction Co., 13th and Greenbush Sts., Lafayette, Ind.	{ A Aug. 6, 1889 M Oct. 1, 1889
BAUER, A. H.	Electrical Engineer, Pullman Palace Car Co., Room 307, Pullman Building, Chicago, Ill.	{ A Feb. 7, 1890 M Apr. 21, 1891
BAYLES, ROBERT N.	Electrician, The "C & C" Electric Motor Co., 404 Greenwich St., New York.	{ A Oct. 1, 1889 M May 17, 1892
BAYLY, B.	Surveyor and District Engineer, Western District Colonial Gov't. Cape Town, Cape of Good Hope, Africa.	{ A Oct. 4, 1887 M Dec. 6, 1887
BELL, PROF. A. GRAHAM	(<i>Past-President.</i>) Beinn Bhreagh, Victoria Co., Cape Breton, N.S.	{ A April 15, 1884 M Oct. 21, 1884
BELL, DR. LOUIS,	(<i>Manager.</i>) Electrical Engineer, Thomson Houston Electric Co., Lynn, Mass.	{ A May 20, 1890 M June 17, 1890
BENJAMIN, PARK	Electrical Expert and Engineer, 32 Park Place, N. Y. City.	{ A Dec. 16, 1891 M Feb. 16, 1892
BERNARD, EDGAR G.	Electrical Engineer, E. G. Bernard & Co., Hall Building, Troy, N. Y.	{ A Jan. 5, 1886 M July 12, 1887
BINNEY, HAROLD	Assistant in the Practice of Patent Law, with Gilbert M. Plympton, 245 Broadway, New York City.	{ A Sept. 16, 1890 M Dec. 16, 1890
BIRDSALL, E. T. M. E.	Electrical Engineer, 18 Broadway, New York.	{ A June 8, 1887 M Nov. 1, 1887
BISHOP, JAMES DRAPER	Electrical Expert, John A. Roebings' Sons Co., 345 W. 34th St., New York City.	{ A Dec. 16, 1891 M Oct. 25, 1892
BLAKE, EDWARD	361 Temple Street, New Haven, Conn.	{ A May 24, 1887 M Sept. 3, 1889
BLAKE, FRANCIS	Auburndale, Mass.	{ A Sept. 3, 1889 M Oct. 1, 1889
BLODGETT, GEO. W.	Electrical Engineer B. & A. R. R. and Consulting Electrician, Boston, Mass.	{ A July 12, 1887 M Sept. 6, 1887
BOSCH, ADAM	Sup't, Fire Alarm Telegraph, Newark, N. J.	{ A April 15, 1884 M Jan. 6, 1885
BOURNE, FRANK	Electrical Engineer, The Field Engineering Co., 143 Liberty St., New York City.	{ A April 21, 1891 M Nov. 15, 1892
BOYNTON, EDWARD C. JR.	Electrician of the Lowell Mfg. Co., Ltd., Erie, Pa.	{ A Aug. 6, 1889 M Nov. 24, 1891
BRADLEY, CHAS. S.	Electrical Engineer, Wayne Hotel, Fort Wayne, Ind.	{ A May 24, 1887 M Dec. 6, 1887
BROOKS, MORGAN	Secretary and Treasurer, The Electrical Engineering & Supply Co., 413 Jackson St., and 529 Holly Ave., St. Paul, Minn.	{ A May 20, 1890 M June 17, 1890
BROWN, J. STANFORD	Consulting Electrical Engineer, Nefel & Marsh Company, 126 Liberty St., New York City.	{ A Sept. 6, 1887 M Nov. 1, 1887

Name.	Address.	Date of Membership.
BRUSH, CHAS. F.	Electrical Engineer, 956 Euclid Ave, Cleveland, O.	{ A April 15, 1884 M Oct. 21, 1884
BURLEIGH, CHAS. B.	Sup't. Isolated Dep't. Thomson- Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	{ A April 21, 1891 M Feb. 16, 1892
BYLLESBY, HENRY M.	Northwest Thomson-Houston Electric Co., 403 Sibley St., St. Paul, Minn.	{ A Sept. 7, 1888 M Oct. 2, 1888
CAHOON, JAS. B.	Electrical Engineer, Thomson- Houston Electric Co., 68 Baker St., Lynn, Mass.	{ A June 17, 1890 M May 19, 1891
CARROLL, LEIGH	President and General Manager, The Edison Electric Illumina- ting Co., Birmingham, Ala.	{ A Oct. 1, 1889 M Nov. 12, 1889
CHAMBERLAIN, J. C.	(Manager.) Electrical Engineer, 136 Liberty St., and 135 East 18th St., New York City.	{ A Dec. 6, 1887 M Jan. 3, 1888
CHANDLER, CHARLES F.	Professor of Chemistry, Columbia College, and Prof. of Chemistry and Physics, College of Physi- cians and Surgeons, New York City.	{ A Jan. 20, 1891 M June 7, 1892
CHURCHILL, ARTHUR.	Engineering Dept., Schenectady Works, General Elec. Co., 23 Front St., Schenectady, N. Y.	{ A April 15, 1890 M Jan. 17, 1893
CLARK, ERNEST P.	Electrical Engineer, Clark Electric Co., 192 Broadway, New York City.	{ A Jan. 8, 1887 M Nov. 1, 1887
CLARKE, CHAS. L.	Mechanical and Electrical Engi- neer, 55 Liberty St., New York City.	{ A April 15, 1884 M Jan. 6, 1885
COLBY, EDWARD A.	Lock Box 313. Newark, N. J.	{ A April 2, 1889 M May 7, 1889
CONDICT, G. HERBERT	General Manager, The Electric Car Co. of America, 4720 Green St., Germantown, Pa.	{ A July 12, 1887 M Sept. 6, 1887
COTHREN, WM. H.	[Address unknown.]	{ A Aug. 6, 1889 M Oct. 1, 1889
COWLES, ALFRED H.	Technical Adviser to the Cowles Smelting and Aluminum Co., 656 Prospect St., Cleveland, O.	{ A Mar. 5, 1889 M May 7, 1889
CROCKER, FRANCIS B. [Life Member.]	Instructor in Electrical Engineer- ing, School of Mines, Columbia College, and 54 W. 21st Street, New York.	{ A May 24, 1887 M April 2, 1889
CROSS, PROF. CHAS. R.	Thayer Professor of Physics, and Director of the Rogers Labora- tory, Mass. Institute of Tech- nology, Boston, Mass.	{ A April 15, 1884 M Oct. 21, 1884
CURTISS, GEORGE F.	Electrician, Bureau of Informa- tion, General Electric Co., 620 Atlantic Ave., Boston, Mass.	{ A April 2, 1889 M Nov. 24, 1891

MEMBERS.

Name.	Address.	Date of Membership.
CUTTER, GEORGE	Dealer in Electrical Supplies, 315 South Canal St., Chicago, Ills.	{ A June 17, 1890 M May 19, 1891
CUTTRISS, CHAS.	Electrician, The Commercial Cable Co., 1 Broad St., New York.	{ A Nov. 1, 1887 M Dec. 6, 1887
DAFT, LEO	Consulting Electrical Engineer and Contractor, Burke Building, Seattle, Wash.	{ A Dec. 9, 1884 M Jan. 6, 1885
DANVERS, ALAN	Managing Director and Chief Electrician, The Anglo-Portuguese Telephone Co., L't'd. 60 Travessa Santa Justa, Lisbon, Port'l.	{ A Nov. 1, 1887 M Sept. 3, 1889
DANVERS, ERNESTO	Electrical Engineer, Casilla 74, Rosario, Argentine Republic.	{ A Jan. 3, 1888 M May 1, 1888
DAVIES, JOHN E.	Professor of Physics, University of Wisconsin, 523 Carroll St. Madison, Wis.	{ A Jan. 7, 1890 M Mar. 18, 1890
DAVIS, CHARLES H.	Consulting Electrical Engineer, 120 Broadway, New York City.	{ A Mar. 18, 1890 M June 17, 1890
DELAFIELD, A. FLOYD, <i>Ph.D.</i>	Electrical Engineer, Noroton Conn.	{ A May 7, 1889 M Oct. 1, 1889
DELANY, PATRICK BERNARD, (<i>Manager</i>).	Inventor, South Orange, N. J.	{ A April 15, 1884 M Nov. 24, 1891
DICKENSON, SAMUEL S.	Sup't, Commercial Cable Co., Hazel-Hill, Guysborough Co., N.S.	{ A Mar. 6, 1888 M Oct. 1, 1889
DIEHL, PHILIP	Inventor, Singer Sewing Machine Co., 508 Morris Ave., Elizabeth, N. J.	{ A April 15, 1884 M Dec. 9, 1884
D'INFREVILLE, GEORGES	Electrical Engineer and Expert, 434 Canal St., New York City.	{ A Nov. 1, 1887 M Dec. 6, 1887
DOIJER, H.	Consulting Electrical Engineer, Oude-delft 222, Delft, Holland.	{ A Jan. 7, 1890 M Mar. 18, 1890
DONNER, WILLIAM H.	Sprague Elevator Co., 114 W. 30th St., New York City.	{ A Nov. 18, 1890 M Dec. 16, 1890
DUDLEY, CHARLES B.	Chemist and Scientific Expert, Penn R. R. Co., 1219 Twelfth Ave., Altoona, Pa.	{ A Oct. 1, 1889 M Nov. 12, 1889
DUNCAN, DR. LOUIS	(<i>Vice-President</i>). Johns Hopkins University, Baltimore, Md., Firm of Sprague, Duncan & Hutchinson, 15 Wall St., New York City.	{ A July 12, 1887 M Sept. 6, 1887
DUNSTON, ROBERT EDWARD,	Room 86, Foster Block, Hartford, Conn.	{ A Oct. 27, 1891 M Feb. 16, 1892
DYER, R. N.	Patent Attorney, 36 Wall St., New York City.	{ A July 12, 1887 M Sept. 6, 1887
EDISON, THOMAS A.	Mechanician and Inventor, Orange, N. J.	{ A April 15, 1884 M Oct. 21, 1884
EMERY, CHARLES EDWARD	Consulting Engineer, Bennett Building, cor. Fulton and Nassau Sts., New York City.	{ A June 26, 1891 M April 19, 1892
EUSTIS, HERBERT H.	President and Electrician, Eastern Electric Cable Co., 61 Hampshire St., Boston, Mass.	{ A April 15, 1890 M Nov. 24, 1891

MEMBERS.

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Name.	Address.	Date of Membership.
FARNHAM, ISAIAH H.	Electrician for the N. E. Telephone & Telegraph Co., 125 Milk St., Boston, Mass.	{ A June 8, 1887 M July 12, 1887
FESSENDEN, REGINALD A.	[Address unknown.]	{ A Oct. 21, 1890 M Dec. 16, 1890
FIELD, C. J.	President and General Manager Field Engineering Co., 143 Liberty St., New York City.	{ A June 8, 1887 M Nov. 1, 1887
FIELD, STEPHEN D.	Electrician and Inventor, Yonkers, N. Y.	{ A April 15, 1884 M Oct. 21, 1884
FLEMING, WILFRID H.	Trask Avenue, Bayonne City, N. J.	{ A Dec. 6, 1887 M Jan. 3, 1888
FOSTER, HORATIO A.	(Manager.) Electrical Engineer, 548 E. 164th St., New York City.	{ A June 8, 1887 M Sept. 6, 1887
FREEMAN, DR. FRANK L.	Attorney-at-Law, Solicitor of Patents, Electrical Expert. 931 F St., Washington, D. C.	{ A May 7, 1889 M Sept. 3, 1889
GEYER, DR. WM. E.	Stevens Institute of Technology, Hoboken, N. J.	{ A June 5, 1888 M Sept. 7, 1888
GRAY, ELISHA DR.	Electrician and Inventor, Highland Park, Ill.	{ A Feb. 16, 1892 M May 17, 1892
GRISCOM, WM. W.	Haverford College P. O., Montgomery Co., Pa. President, The Electro Dynamic Co., 224 Carter St., Philadelphia, Pa.	{ A June 5, 1888 M Mar. 18, 1890
HALL, CLAYTON C.	Civil Engineer, 810 Park Ave., Baltimore, Md.	{ A April 15, 1884 M Oct. 21, 1884
HAMBLET, JAMES	(Manager) Manager Time Service, W. U. Tel. Co., 195 Broadway, P. O. Box 3393, New York City.	{ A Nov. 1, 1887 M Dec. 6, 1887
HAMILTON, GEO. A.	Electrician, Western Electric Co., 22 Thames cor. Greenwich St., New York, and 532 ¹ / ₂ Morris Ave., Elizabeth, N. J.	{ A April 15, 1884 M Oct. 21, 1884
HAMMER, W. J.	(Vice-President.) Consulting and Supervising Electrical Engineer, 527 Temple Court, N. Y., and 23 Rowland St., Newark, N. J.	{ A June 8, 1887 M July 12, 1887
HASKINS, CHARLES H.	Electrician, 80 Broadway, New York City.	{ A April 15, 1884 M Oct. 21, 1884
HAYES, HAMMOND V.	Electrician, American Bell Telephone Co., 127 Purchase St., Boston, Mass.	{ A Nov. 12, 1889 M Mar. 18, 1890
HAYNES, F. T. J.	Divisional Telegraph Engineer, Great Western Railway, Taunton, Eng.	{ A Dec. 6, 1886 M Jan. 3, 1887
HEINRICH, RICHARD O.	Electrical Engineer, Weston Electrical Instrument Co., 114 William St., Newark, N. J.	{ A Oct. 1, 1889 M Oct. 25, 1862

MEMBERS.

Name.	Address.	[Date of Membership.
HERRING, CARL	(Vice-President.) Editor <i>Electrical World</i> , and Consulting Electrical Engineer, 3816 Spring Garden St., Philadelphia, Pa.	{ A Jan. 3, 1888 M June 5, 1888
HERRICK, CHARLES H.	Manager and Electrical Engineer, Wright Electrical Engineering Co., 196 Summer St., Boston, Mass.	{ A April 21, 1891 M Jan. 17, 1893
HERZOG, DR. F. BENEDICT	President Herzog Teleseme Co., 30 Broad St., New York City.	{ A May 24, 1887 M July 12, 1887
HEWITT, CHARLES	The Edison General Electric Co., Edison Building, Broad St., Box 3067, New York City.	{ A Sept. 16, 1890 M May 17, 1892
HIBBARD, ANGUS S.	(Manager). General Superintendent, American Telephone and Telegraph Co., 18 Cortlandt St., New York City.	{ A Nov. 24, 1891 M Feb. 16, 1892
HIGGINS, EDWARD E.	Street Railway and Financial Counsel, Mills Building 35 Wall St., New York City.	{ A June 8, 1887 M July 12, 1887
HOUSTON, PROF. EDWIN J.	Prof. of Physics, Franklin Inst., Prof. of Physics and Physical Geography, Central High School, 1809 Spring Garden St., Philadelphia, Pa.	{ A April 15, 1884 M Oct. 21, 1884
HOWELL, JOHN W.	Electrician, Edison Lamp Works, Harrison N. J.	{ A July 12, 1887 M June 5, 1888
HOWELL, WILSON S.	Electrical Expert, Edison Lamp Works, Harrison, N. J.	{ A Sept. 3, 1889 M Mar. 18, 1890
HUNTER, RUDOLPH M.	Mechanical and Elect'al Engineer, 926 Walnut St., Philadelphia, Pa.	{ A July 13, 1886 M May 17, 1887
HUTCHINSON, DR. CARY T.	Electrical Engineer, 56 West 25th St., Firm of Sprague, Duncan & Hutchinson, 15 Wall St., New York City.	{ A Feb. 7, 1890 M Dec. 16, 1890
HYDE, JEROME W.	Springfield, Mass.	{ A June 8, 1887 M Nov. 1, 1887
INRIG, ALEC GAVAN	Rue St. Gommaire, 23, Antwerp, Belgium.	{ A Jan. 19, 1892 M May 17, 1892
JACKSON, DUGALD C.	Professor of Electrical Engineering University of Wisconsin, Madison, Wis.	{ A May 3, 1887 M June 17, 1890
JACKSON, FRANCIS E.	With Edison Lamp Works, Harrison N. J.	{ A Jan. 3, 1888 M June 17, 1890
JANNUS, FRANKLAND	Solicitor of Patents, 928-30 F. St. Washington. D. C.	{ A Nov. 12, 1889 M Mar. 18, 1890
JENKS, W. J.	Technical Department, General Electric Co., 44 Broad Street, Box 3067, New York City.	{ A June 8, 1887 M Nov. 1, 1887
JONES, FRANCIS W. [Life Member.]	Assistant Gen'l-Manager and Electrician, Postal-Telegraph Cable Co., 5 Dey St., New York City.	{ A April 15, 1884 M Oct. 21, 1884

MEMBERS.

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Name.	Address.	Date of Membership.
KNOWLES, E. R.	Chief Electrician, The Schuyler Electric Company, Middletown, Conn.	{ A June 8, 1887 M July 12, 1887
KNUDSON, A. A.	Manager, Eastern Electric Co., St. John, N. B. Room 37, Drexel Bldg., New York City.	{ A Dec. 6, 1887 M Jan. 3, 1888
LANGE, PHILIP A.	Assistant Superintendent Westinghouse Electric and Manufacturing Co., Newark, N. J.	{ A Mar. 6, 1888 M June 5, 1888
LANGTON, JOHN	Electrical Engineer, Canada Life Building, Toronto, Ont.	{ A Mar. 6, 1888 M June 5, 1888
LATTIG, J. W.	Electrical Engineer, National Switch & Signal Co., and 1029 Arlington Terrace, Easton, Pa.	{ A June 8, 1887 M July 12, 1887
LAWSON, A. J.	Electrical Engineer and Contractor, Grantown, Scotland.	{ A Mar. 18, 1890 M June 17, 1890
LEONARD, H. WARD	(Manager). General Manager, The H. Ward Leonard Co., 136 Liberty St., New York City.	{ A July 12, 1887 M Sept. 6, 1887
LEONARD, M. B.	Electrical Engineer, and Supt. of Telegraph, Chesapeake & Ohio R'y. Co., Richmond, Va.	{ A Nov. 6, 1886 M May 1, 1888
LIEB, JOHN W., JR.	Chief Engineer, Società Generale Italiana di Elettricità (Sistema Edison). Via S. Radigonda N. 4, Milan, Italy.	{ A Sept. 6, 1887 M Nov. 1, 1887
LOCKWOOD, THOMAS D. [Life Member.]	(Vice-President.) Electrical Engineer, and Advisory Electrician, P. O. Drawer 2, Boston, Mass.	{ A April 15, 1884 M Oct. 21, 1884
LYNE, LEWIS F.	Mechanical and Elect'al Engineer, 307 Grove St., Jersey City, N. J.	{ A Jan. 3, 1888 M June 5, 1888
MACFARLANE, ALEXANDER	Professor of Physics, University of Texas, Austin, Texas.	{ A Jan. 19, 1892 M May 17, 1892
MAILLOUX, C. O.	Consulting Electrical Engineer, 45 William St., New York City.	{ A April 15, 1884 M Oct. 21, 1884
MARKS, WILLIAM DENNIS,	PA. B., C. E. Edison Electric Light Co., Philadelphia, Pa.	{ A Feb. 7, 1888 M May 1, 1888
MARSHALL, J. T.	Inspector of Lamp Manufacture, Edison Lamp Works, Harrison, N. J.	{ A Oct. 1, 1889 M Nov. 12, 1889
MARVIN, HARRY N.	Secretary and Expert, Marvin Electric Drill Co., Schenectady, N. Y.	{ A April 19, 1892 M Jan. 17, 1893
MAVER, WILLIAM, JR.	Electrical Expert, 31 Nassau St., New York City.	{ A July 12, 1887 M Apr. 21, 1891
MAYNARD, GEO. C.	Electrical Engineer, 1409 New York Ave., Washington, D. C.	{ A April 15, 1884 M Dec. 9, 1888
MCCAV, H. K.	Electrician, 106 E. German St., Baltimore, Md.	{ A Sept. 16, 1890 M May 19, 1891
METCALFE, GEORGE R.	Electrical Engineer, Editor <i>Electricity</i> , 6 Park Place, and 404 W. 22d Streets, New York City.	{ A April 19, 1892 M Nov. 15, 1892

Name.	Address.	Date of Election.
MILLIS, JOHN	Lieutenant of Engineers, U. S. Army, 1 Prytania St., New Orleans, La.	{ A July 7, 1884 M Mar. 3, 1885
MILLS, FRANK P.	Superintendent Cleveland Iron Mining Co., Ishpeming, Mich.	{ A Jan. 6, 1885 M Mar. 3, 1885
MOLERA, E. J.	Civil Engineer, 40 California St., San Francisco, Cal.	{ A Jan. 16, 1892 M June 7, 1892
NICHOLS, DR. EDWARD L.	Professor of Physics, at Cornell University, Ithaca, N. Y.	{ A Oct. 4, 1887 M Dec. 6, 1887
PAINK, SIDNEY B.	Manager, Mill Power Dep't, General Electric Co., 620 Atlantic Ave., Boston, Mass.	{ A June 8, 1887 M Nov. 1, 1887
PAINK, F. B. H.	Siemens and Halske Co., Room 803, Bank of Commerce Bldg., St. Louis, Mo.	{ A Dec. 16, 1890 M Nov. 25, 1891
PARKS, C. WELLMAN	Electrician, 1825 Fifth Ave., Troy, N. Y.	{ A July 12, 1887 M May 1, 1888
PARSHALL, H. F.	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	{ A Sept. 7, 1888 M Mar. 18, 1890
PATTISON, FRANK A.	Firm of Pattison Bros., Consulting and Constructing Electrical Engineers, 135 Broadway, New York City.	{ A Sept. 22, 1891 M Dec. 16, 1891
PERRINE, FREDERIC A. C.	Care Germania Electric Co., 620 Atlantic Ave., Boston, Mass.	{ A Sept. 16, 1890 M Dec. 16, 1890
PHELPS, GEO. M.	(Treasurer). President, Electrical Engineer, 203 Broadway, New York.	{ A April 15, 1884 M Oct. 21, 1884
PICKERNELL, F. A.	Sup't. of Equipment, Amer. Tel. & Tel. Co., 153 Cedar St., New York City.	{ A Feb. 7, 1890 M Mar. 18, 1890
PIKE, CLAYTON W.	James W. Queen & Co., 1010 Chestnut St., Philadelphia, Pa.	{ A Dec. 16, 1891 M Oct. 25, 1892
POPE, FRANKLIN L.	(Past President). Consulting Electrical Engineer and Expert, 15 Wall St., N. Y. Residence, Elizabeth, N. J.	{ A April 15, 1884 M Oct. 21, 1884
PORTER, J. F.	Representing J. G. White & Co., of New York, Heist Building, Kansas City, Mo.	{ A Sept. 6, 1887 M Nov. 1, 1887
PRATT, ROBERT J.	Electrician. Treas. and Mgr. Electric Mfg. Co. and Gas Engine Co., Greenbush, N. Y.	{ A July 12, 1887 M Sept. 6, 1887
PRESCOTT, GEO. B., JR.	Electrical Engineer. The Stanley Laboratory Co., Pittsfield, Mass.	{ A July 12, 1887 M Nov. 1, 1887
RAE, FRANK B.	Electrical Engineer, 27 and 28 Cleland Building, 31st St., Detroit Mich.	{ A April 15, 1884 M Oct. 25, 1892
RAYMOND, CHAS. W.	Civil, Electrical and Mining Engineer, Monte Vista, Col.	{ A June 8, 1887 M May 17, 1887

MEMBERS.

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Name.	Address.	Date of Election.
RECKENZAUN, ANTHONY	Electrical Engineer, 7 Albert Terrace, Hemberton Road, Stockwell, London, S. W. England.	{ A Nov. 1, 1887 M Dec. 6, 1887
RECKENZAUN, FREDERICK	Electrician, Box 225, West Hoboken, N. J.	{ A Mar. 6, 1888 M June 5, 1888
RICE, E. WILBUR, JR.	Technical Director, The General Electric Co., Lynn, Mass.	{ A Dec. 6, 1887 M Jan. 3, 1888
RIES, ELIAS E.	Electrician and Electrical Engineer, 430 South Broadway, Baltimore, Md.	{ A July 12, 1887 M Sept. 6, 1887
ROBB, WM. LISPENARD	Professor of Physics, Trinity College, Hartford, Conn.	{ A Dec. 16, 1891 M Mar. 15, 1892
ROBERTS, E. P.	Electrician and Sup't, Swan Lamp Co., Belden St., Cleveland, O.	{ A Jan. 6, 1885 M Feb. 3, 1885
ROHREK, ALBERT L.	Electrical Engineer, with General Electric Co., Schenectady, N. Y.	{ A Nov. 1, 1887 M May 1, 1888
SALOMONS, Sir DAVID LIONEL [Life Member.]	<i>Bart. M. A.</i> , Engineer and Barrister, Broomhill, Tunbridge Wells, Kent, and 49 Grosvenor St., London, W., England.	{ A Feb. 7, 1888 M May 1, 1888
SCHULZE-BERGE, FRANZ	44 Monroe Place, Brooklyn, N. Y.	{ A Nov. 12, 1889 M Mar. 18, 1890
SCOTT, CHARLES F.	Assistant Electrician, Westinghouse Electric and Mfg. Co., Pittsburg, Pa.	{ A April 19, 1892 M Jan. 17, 1893
SHALLENBERGER, O. B.	Electrician, Westinghouse Electric Co., Pittsburg, Pa.	{ A Sept. 7, 1888 M Dec. 4, 1888
SHELDON, SAMUEL, A. M. Ph. D.	Professor of Physics and Electrical Engineering, Polytechnic Institute, 170 State St., Brooklyn, N. Y.	{ A Dec. 16, 1890 M Oct. 27, 1891
SHEPARD, WM. E.	Lincoln St. Ry. Co., Lincoln, Neb.	{ A Feb. 7, 1890 M Mar. 18, 1890
SLATER, HENRY B.	Manager and Sup't, The Canon City Electric Light and Power Co., Canon City Col.	{ A April 15, 1884 M Dec. 9, 1884
SMITH, JESSE M.	Consulting Electrical Engineer and Expert in Patent Causes, 36 Moffatt Block, Detroit, Mich.	{ A April 15, 1884 M June 26, 1891
SMITH, T. CARPENTER	Partner in firm of M. R. Muckle Jr. & Co., 212 Drexel Building, Philadelphia, Pa.	{ A Oct. 27, 1891 M Dec. 16, 1891
STANDFORD, WILLIAM	Ass't Sup't Telegraphs, Colonial Gov't, Cape Town, Cape of Good Hope, Africa.	{ A Oct. 4, 1887 M Dec. 6, 1887
STEBBINS, THEODORE	Superintendent Railway Construction, General Electric Co., 620 Atlantic Ave., Boston, Mass.	{ A July 9, 1889 M June 17, 1890
STEINMETZ, CHARLES P.	(Manager.) Electrician, Osterheld & Eickemeyer, 124 Waverly Place, Yonkers, N. Y.	{ A Mar. 18, 1890 M April 21, 1891
STIERINGER, LUTHER	Electrical Expert, 1873 Lexington Ave., New York.	{ A June 8, 1887 M Nov. 1, 1887

MEMBERS.

Name.	Address.	Date of Election.
STILLWELL, LEWIS B.	Electrical Engineer, Westinghouse Electric and M'fg Co., Pittsburg, Pa.	{ A April 19, 1862 M Nov. 15, 1892
TAINTOR, GILES	Division Supt., Western Division New England Telephone and Telegraph Co. Springfield, Mass.	{ A June 26, 1891 M Dec. 16, 1891
TALTAVAL, THOS. R.	Editor, <i>Electrical Age</i> , World Building, New York City.	{ A Jan. 20, 1891 M Oct. 27, 1891
TERRY, CHARLES A.	Lawyer, Westinghouse Electric and M'fg. Co, Pittsburg, Pa.	{ A April 5, 1887 M May 17, 1887
THOMAS, BENJAMIN F.	Professor of Physics, Ohio State University, Columbus, O.	{ A June 7, 1892 M Nov. 15, 1892
THOMSON, PROF. ELIHU	(Past President). Electrician, Thomson Houston Electric Co., and Thomson Electric Welding Co., Lynn, Mass.	{ A April 15, 1884 M April 21, 1891
THOMPSON EDWARD P.	Consulting Electrician and Patent Attorney in Electrical Cases, 5 Beekman St., New York City.	{ A April 15, 1884 M Dec. 3, 1889
THURNAUER, ERNST	Manager, Thomson-Houston International Elec. Co., 7 Rue du Louvre, Paris, France.	{ A Oct. 14, 1887 M Dec. 6, 1887
TURNER, WILLIAM S.	President, Woodbridge & Turner Engineering Co., 47 Times Building, New York City.	{ A Dec. 7, 1886 M Oct. 2, 1888
UPTON, FRANCIS R.	General Manager, Edison Lamp Works, Harrison, N. J. Residence, 107 Day St., Orange, N. J.	{ A May 17, 1887 M Mar. 15, 1892
VAIL, J. H.	Ass't Engineer in Chief, General Electric Co., Edison Building, P. O. Box 3067, New York City.	{ A June 8, 1887 M Nov. 1, 1887
VANSIZE, WILLIAM B.	Solicitor of Patents, 44 Broad St., New York City.	{ A April 15, 1884 M Oct. 21, 1884
WADDELL, MONTGOMERY	Engineer, The Waddell-Entz Electric Co., Bridgeport, Conn.	{ A Feb. 7, 1888 M May 1, 1888
WALDO, DR. LEONARD	Electrical Engineer, Firm of Waldo & Stout, Aluminum, Silicon and Manganese Bronze Founders, Bridgeport, Conn.	{ A June 5, 1888 M Dec. 4, 1888
WALKER, SYDNEY F.	Electrical Engineer, 195 Severn Road, Cardiff, Wales.	{ A June 2, 1885 M May 17, 1887
WEAVER, W. D.	32 West 31st Street, New York City.	{ A May 17, 1887 M May 17, 1887
WEBB, HERBERT LAWS	(Manager) 26 West 34th Street, New York City.	{ A Oct. 21, 1890 M Dec. 16, 1890
WEEKS, EDWIN R.	General Manager, Kansas City Electric Light Co., National Bank of Kansas City Building, Kansas City, Mo.	{ A Sept. 6, 1887 M Nov. 1, 1887
WELLER, HARRY W.	Railroad Inspector, The General Electric Co., Edison Building, Broad Street, New York City.	{ A Oct. 21, 1890 M Nov. 24, 1891
WELLS, DOUGLAS	Hurstfield Ave., Gipsy Hill, London, Eng.	{ A June 7, 1892 M Jan. 17, 1893

MEMBERS.

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Name.	Address.	Date of Election.
WESTON, EDWARD	(<i>Past President.</i>) Vice-President, Weston Electrical Instrument Co., 120 William St., and 645 High St., Newark, N. J.	{ A April 15, 1884 M Oct. 27, 1884
WETZLER, JOSEPH	Editor <i>Electrical Engineer</i> , 203 Broadway, New York City.	{ A April 15, 1884 M Dec. 9, 1884
WHARTON, CHAS. J.	82 Bond St., London England.	{ A Jan. 3, 1888 M May 1, 1888
WHEELER, SCHUYLER S., <i>Sr.D.</i> [Life Member.]	President Crocker-Wheeler Electric Motor Co., 430-432 West Fourteenth St., Electrical Expert, Board of Electrical Con- trol, 1266 Broadway, New York City.	{ A June 2, 1885 M Sept. 1, 1885
WILKES, GILBERT	Chief Engineer, Detroit Electrical Works, Detroit, Mich.	{ A Jan. 7, 1890 M Mar. 18, 1890
WILSON, CHARLES H.	General Superintendent, Chicago Telephone Co., 203 Washington Street, Chicago, Ill.	{ A Nov. 24, 1891 M Feb. 16, 1892
WILSON, FREMONT	Consulting Electrical Engineer, Times Building, and 203 Lenox (6) Ave., New York City.	{ A Mar. 6, 1888 M June 5, 1888
WILSON, HARRY C.	Supt. of F. O. Telegraph with the Government, Kingston, Jamaica, West Indies.	{ A Jan. 19, 1891 M June 7, 1892
WINCHESTER, A. E.	Designer of Steam Electrical Plants, Wilton, Conn.	{ A June 8, 1887 M Nov. 1, 1887
WOLCOTT, TOWNSEND	Consulting Electrician, 849 Greene Ave., Brooklyn, N. Y.	{ A Mar. 6, 1888 M Dec. 16, 1890
WOODBIDGE, J. L.	Secretary and Treasurer, Wood- bridge & Turner Engineering Co., 47 Times Building, New York City.	{ A June 8, 1887 M Nov. 1, 1887
WURTS, ALEXANDER JAY,	Electrical Expert, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.	{ A April 19, 1892 M Nov. 15, 1892
YOUNG, C. GRIFFITH	Electrical Engineer, Care J. G. White & Co., 29 Broadway, New York City.	{ A Jan. 3, 1889 M April 21, 1891
ZETTSCHKE, PROF. DR. CARL EDUARD,	Telegraph Engineer, Carl- strasse 13, Dresden, N., Saxony.	{ A Nov. 1, 1887 M Jan. 3, 1888

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ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
ABERNETHY, J. P.	Superintendent of Telegraph, 53 City Hall, Cleveland, O.	July 7, 1884
ABBOTT, ARTHUR V.	Mechanical Engineer, North Ave. Railway Co., Blackstone Building, Baltimore, Md.	Oct. 21, 1890
ALBRIGHT, H. FLEETWOOD	Electrical Engineer, Western Electric Co., 227 S. Clinton St., Chicago, Ill.	Sept. 27, 1892
ALDEN, JAMES S.	Assistant Manager, with L. H. Alden, 486 River Drive, Passaic, N. J.	May 19, 1891
ALDRICH, WILLIAM S.	Burlington, N. J.	Mar. 15, 1892
ALEXANDER, HARRY	Electrical Contractor, 126 Liberty and 340 W. 145th St., New York City.	April 21, 1891
ALEXANDER, P. H.	Southern Electric Co., Hoen Building, Baltimore, Md.	Dec. 16, 1890
ANDREWS, WM. S.	General Electric Co., Montreal, Canada.	Mar. 5, 1889
ANTHONY, WATSON G.	Electrician, 324 Webster St., Newark, N. J.	Feb. 24, 1891
ARMSTRONG, CHAS. G.	Electrical Expert and Electrical Architect, 1301 Auditorium Tower Chicago, Ill.	Sept. 27, 1892
ARNOLD, BION J.	Consulting Engineer, General Electric Co., 4128 Prairie Ave., Chicago, Ill.	Oct. 25, 1892
ARNOLD, CRAIG R.	Electrician and Treasurer, Arnold Electric Mfg. Co., Chester, Penn.	Nov. 15, 1892
ATWOOD, GEORGE F.	Orange, N. J.	Sept. 16, 1890
BADT, LIEUT. FRANCIS B.	Manager, Mining Dep't. T.-H. Electric Co., 6506 Lafayette Ave., Englewood, Ill.	April 19, 1892
BAILLARD, E. V.	Equitable Mfg. and Electric Co., 611 West 36th St. and 363 Manhattan Ave., New York City.	Dec. 3, 1889
BARNARD, JOHN H.	Vice President and General Manager, Wilmington Street Railway Co., Wilmington, N. C.	June 26, 1891.
BARTON, ENOS M.	President Western Electric Co., 227 South Clinton St., Chicago, Ill.	July 12, 1887
BARRETT, JOHN A.	Electrical Engineer and Expert, 13 Park Row, New York City.	June 8, 1887
BATES, F. C.	Electrical Engineer, with Thomson-Houston Electric Co., Lynn, Mass.	Jan. 20, 1891
BAUER, W. F.	Electrician, 62 Steuben St., East Orange, N. J.	April 15, 1890
BEALS, PASCAL P.	Electrical Contractor and Agent for the Waddell-Entz Electric Co., 50 Terrace, Buffalo, N. Y.	May 17, 1892
BEATTIE, JOHN, JR.	Manager and Superintendent, The Beattie Battery, Zinc and Electric Co., Fall River, Mass	Sept. 6, 1887

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
BEDDELL, FREDERICK, DR.	Physical Laboratory, Cornell University, Address, 118 Elm St., Montclair, N. J.	April 21, 1891
BENNETT, J. C.	Electrician, General Electric Co., Box 3067, 44 Broad St., New York City.	Mar. 18, 1890
BERHGOLTZ, HERMAN	Secretary and Treasurer, Ithaca Street Railway Co., Ithaca, N. Y.	April 2, 1889
BERLINER, EMILE	Inventor, Columbia Road, between Fourteenth and Fifteenth Sts., Washington, D. C.	April 15, 1884
BERTHOLD, VICTOR M.	With T. D. Lockwood in Patent Department of American Bell Telephone Co., 16 Upton Street, Cambridgeport, Mass.	May 17, 1892
BLACK, CHAS. N.	Brush Electric Co., Belden St., Cleveland, O.	Feb. 7, 1890
BLADES, HARRY H.	General Sup't., The Detroit Motor Co., 1343-55 Cass Ave., Detroit, Mich.	April 19, 1892
BLAKE, HENRY W.	The Street Railway Publishing Co., World Building, New York City.	Nov. 13, 1888
BLAKENEY, W. H.	Firm of Blakeney and Rennie, Mechanical and Electrical Engineers, 33 Bath St., Glasgow, Scotland.	Mar. 15, 1892
BLISS, DONALD M.	Electrician, The Canada Electric Co., Amherst, N. S.	Feb. 7, 1890
BLISS, WM. J. A.	820 Connecticut Ave., Washington, D. C.	Jan. 20, 1891
BLOOD, W. HENRY, JR.	The Franklin Electric Co., 535 Delaware St., Kansas City, Mo.	April 2, 1889
BLUME, JOHN C.	Assistant Electrician, American Telegraph and Telephone Co., 23 East 31st., New York City.	Dec. 21, 1892
BOGART, A. LIVINGSTON	Electrical and Patent Expert, 22 Union Square, New York City.	July 10, 1888
BOGUE, CHARLES J.	165 West Eighteenth St., New York.	Dec. 3, 1889
BOHM, LUDWIG K. <i>Ph.D.</i>	Consulting Electrical & Chemical Expert, 81 Nassau St., New York City.	Nov. 15, 1892
BOSSON, FREDERICK N.	Electrician, Calumet and Hecla Mining Co., Calumet, Mich.	May 17, 1892
BOTTOM, TURNER D.	Electrician and General Manager, White House Mills, Hoosick, N. Y.	April 21, 1891
BOTTOMLEY, HARRY	Electrical Engineer, Marlboro, Mass.	April 2, 1889
BOUGHAN, EDWARD L.	Supply Agent, American Telephone and Telegraph Co., 153 Cedar St., New York City.	Dec. 21, 1892
BOWMAN, FRED A.	Supt., New Glasgow Electric Co., New Glasgow, Nova Scotia.	May 10, 1891

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
BRACKETT, PROF. CYRUS F.	Princeton, N. J.	April 15, 1889
BRADDELL, ALFRED E.	Electrical Inspector, Underwriters' Association, Middle Dep't, 308 Walnut St., Philadelphia, Pa.	Sept. 1, 1890
BRADLEY, FRED. W.	Electrical Engineering Dep't, Jackson Park, Chicago, Ill.	May 20, 1890
BRADY, PAUL T.	State Agent, Thomson-Houston Electric Co., Syracuse, N. Y.	July 12, 1887
BROPHY, WILLIAM	17 Egleston St., Jamaica Plain, Mass.	Mar. 5, 1889
BROWN, ALEX. S.	Electrical Engineer, 136 Liberty St., New York City.	Jan. 7, 1890
BROWN, ALFRED S.	Electrical Engineer, Western Union Telegraph Co., 195 Broadway, New York City.	Mar. 18, 1890
BROWN, CHARLES A.	Attorney, Firm of Barton & Brown, Attorneys and Counsellors, 1428 1430 Monadnock Bldg., Chicago, Ill.	July 12, 1887
BUBERT, J. F.	Electrical Engineer, The Mather Electric Co., 116 Bedford St., Boston, Mass.	June 7, 1892
BUCKINGHAM, CHAS. L.	Patent Attorney, Western Union Telegraph Co., 195 Broadway, P. O. Box 3393, New York City.	April 15, 1884
BUNCE, THEODORE D., JR.	[Address unknown.]	May 20, 1890
BURNS, ELMER Z.	Consulting Electrical Engineer, Niagara Falls, N. Y.	Feb. 7, 1890
BURTON, GEO. D.	President, Electrical Forging Co., 194 Washington St., Boston, Mass.	April 21, 1891
BUYS, BERT.	Electrician, Rutherford B. S. & C. Elec. Co., Rutherford, N. J.	Feb. 7, 1890
CALDWELL, EDWARD	Editor, <i>Street Railway Gazette</i> , Phoenix Building, Chicago, Ill.	Jan. 20, 1891
CALDWELL, FORDYCE S.	Proprietor Western Electric Construction Co., 503 Delaware St., Kansas City, Mo. and 151 Henry St., Brooklyn, N. Y.	Sept. 22, 1891
CALLENDER ROMAINE	Electrician, Brantford Electrical Laboratory, Brantford, Canada.	Sept. 27, 1892
CARSON, DAVID I.	Sec'y and Gen. Supt., the Southern Bell Telephone and Telegraph Co., 18 Cortlandt St., New York City.	Dec. 21, 1892
CARTWRIGHT, FRED'K. G.	Electrical Engineer, and Agent Fort Wayne Electric Co., 35 New Montgomery St., San Francisco, Cal.	Sept. 22, 1891
CARTY, J. J.	Electrician, Metropolitan Telephone and Telegraph Co., 18 Cortlandt St., New York City.	April 15, 1890

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Elec. ion.
CASE, WILLARD E.	6 Fort St., Auburn, N. Y.	Feb. 7, 1888
CASPER, LOUIS	Wheatstone Repeater Chief, Western Union Telegraph Co., Cheyenne, Wyoming.	April 21, 1891
CHAMBERLAIN, F. H.	Electrician. Metropolitan R. R. Co., 2411 P St., N. W. Washington, D. C.	June 17, 1890
CHENEY, FREDERICK A.	Sec'y, Treas'r and General Manager, The Elmira Illuminating Co., Elmira, N. Y.	Oct. 1, 1889
CHENEY, W. C.	Electrical Engineer, Willamette Falls Electric Co., Portland, Oregon.	Sept. 22, 1891
CHERMONT, ANTONIO LEITE,	Manager Telephone Co. of Para, Para, U. S. of Brazil, Care Herbst Bros, Box 1377, New York City.	Mar. 18, 1890
CHILDS, W. H.	Bookkeeper for The Estey Organ Co., Brattleboro, Vt.	Sept. 6, 1887
CHINNOCK, C. E.	General Electric Co., Edison Building, P. O. Box 3067, New York City.	April 15, 1884
CHUBBUCK, H. EUGENE	Sec'y and Treas'r, The New Omaha Thomson-Houston Electric Co., Omaha, Neb.	Dec. 4, 1888
CLAFLIN, ADAMS D.	General Manager, The Mather Electric Co., 116 Bedford St., Boston, Mass.	June 7, 1892
CLEMENT, LEWIS M.	1013 Central Ave., Oakland, Cal.	April 21, 1891
CLEVELAND, WM. B.	Electrical Engineer, 309 Perry-Payne Building, Cleveland, O.	April 15, 1884
COBB, JOHN S.	[Address unknown.]	June 17, 1890
COFFIN, CHAS. A.	Vice-President and Treasurer, Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Dec. 6, 1887
COGSWELL, A. R.	Electrician and Superintendent, Halifax Illuminating and Motor Co. Ltd., 34 Bishop St., Halifax, N. S.	April 21, 1891
COLGATE, GEO. L.	[Address unknown.]	June 17, 1890
COLLEY, BENJAMIN W.	First Ass't. Superintendent, The Commercial Cable Co., Hazel Hill, N. S.	Oct. 21, 1890
COLVILLE, FRANK C.	Electrician and Inventor, 1503 Seventh Ave., Oakland, Cal.	May 19, 1891
COMPTON, ALFRED G.	(Manager.) Professor of Physics, College of the City of New York, 17 Lexington Ave., New York City.	Nov. 1, 1887
COOLIDGE, CHARLES A.	Sup't and Electrician, Northern Improvement Co., Centralia, Washington.	April 19, 1892
CORNELL, CHAS. L.	Electrical Engineer, Cornell Engineering Co., 45 Broadway, New York City.	Feb. 7, 1890

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
CORSON, WILLIAM R. C.	Assistant Electrician, The Eddy Electric Mfg. Co., Windsor, Conn.	Jan. 17, 1893
CORY, CLARENCE L.	Professor of Electrical Engineering, University of California, Berkeley, Cal.	April 19, 1892
CRAM, HENRY B.	Treasurer, Bernstein Electric Co., 620 Atlantic Ave., Boston, Mass.	June 26, 1891
CRANDALL, CHESTER D.	Assistant Treasurer, Western Electric Co., 227 South Clinton St., Chicago, Ill.	Sept. 27, 1892
CRANE, W. F. D.	Manager Electrical Dept. H. W. Johns Manufacturing Co., 87 Maiden Lane, New York City, and 24 Halstead Pl., East Orange, N. J.	Feb. 7, 1888
CREHORE, ALBERT CUSHING	Instructor in Physics, Cornell University, 117 East Buffalo St., Ithaca, N. Y.	Dec. 21, 1892
CROSBY, OSCAR T.	(Vice-President.) General Manager Railway Department, General Electric Co., 620 Atlantic Ave., Boston, Mass.	Mar. 18, 1890
CUNTZ, JOHANNES H.	Assistant to Pres't Henry Morton, Stevens Institute of Technology, 137 Hudson St., Hoboken, N. J.	Mar. 5, 1889
CURTIS, CHAS. G.	63 Broadway, New York City.	April 15, 1884
CUSHING, F. W.	General Western Agent, Day's Kerite Wire and Cables, 225 Dearborn St., Chicago, Ill.	Nov. 24, 1891
CUSHMAN, HOLBROOK	Instructor in Physics, Columbia College, 337 West 22d St., New York City.	June 5, 1888
DAME, FRANK L.	Engineer, The Northwest Thomson-Houston Electric Co., 114 James St., Seattle, Wash.	June 26, 1891
DANA, R. K.	Agent Washburn and Moen M'fg Co., 16 Cliff St., New York City.	April 15, 1884
DANIELL, FRANCIS G.	Electrical Engineer, Evansville Street R. R. Co., Evansville, Ind.	Nov. 12, 1889
DAVENPORT, GEORGE W.	General Manager, Thomson-Houston International Electric Co., 44 Broad St., New York City.	June 4, 1889
DAVIDSON, EDW. C.	Patent Lawyer, Room 179 Times Bldg., New York City.	Feb. 7, 1890
DAVIS, DELAMORE L.	Superintendent, Salem Electric Light & Power Co., 299 Lincoln Ave., Salem, O.	April 2, 1889
DAVIS, JOSEPH P.	Consulting Engineer, Care of Phoenix Construction Co., 115 W. 38th St., New York City.	April 15, 1884
DAVIS, MINOR M.	Ass't Electrician, Postal Telegraph Cable Co., 5 Dey St., New York City.	April 6, 1886

Name	Address.	Date of Election.
DE KHOTINSKY, CAPT. ACHILLES,	Superintendent, Germania Electric Co., 505 Exchange Bldg., Boston, and Marlboro, Mass.	Oct. 27, 1891
DE LAND, FRED	Editor, <i>World's Fair Electrical Engineering</i> . The Rookery, Chicago Ill.	Feb. 16, 1892
DENTON, JAMES E.	Professor of Experimental Mechanics, Stevens Institute of Technology, Hoboken, N. J..	July 12, 1887
DESMOND, JERE. A.	Supt. and Electrician, Kingston Electric Light and Power Co., Kingston, N. Y.	Jan. 19, 1892
DICKERSON, E. N.	Attorney-at-Law, 15 Wall St., New York City.	April 15, 1884
DION ALFRED A.	Manager, Ahearn & Soper, 72 Sparks Street, Ottawa, Ont.	Jan. 7, 1890
DOANE, S. EVERETT	Thomson-Houston Electric Co., Swampscott, Mass.	Aug. 6, 1889
DOBBIE, ROBERT S.	Consulting Electrical Engineer, 1014 Bergen Ave., Jersey City, N. J.	Feb. 5, 1889
DOREMUS, CHARLES A.	<i>M. D. Ph. D.</i> Chemist and Physicist, Bellevue Hospital Medical College, College of the City of New York and American Veterinary College, 92 Lexington Ave., New York City.	July 7, 1884
DRESSLER, CHARLES E.	Maker of Scientific and Electrical Apparatus, College of the City of New York, 17 Lexington Ave., New York City.	Dec. 16, 1890
DUNBAR, F. W.	Assistant Electrician, American Telephone and Telegraph Co., 153 Cedar St., New York City.	Dec. 21, 1892
DUNDERDALE, CLEAVELAND F.	Agent Westinghouse Electric Co., 146 Adams St., Chicago, Ill.	June 17, 1890
DUNN, GANO S.	Electrical Engineer, of the Crocker-Wheeler Electric Co., 430 West 14th St., Residence, 223 Central Park, West, New York City.	April 21, 1891
DURANT, EDWARD	Electrician, with F. Pearce, 115 E. 26th St., New York City.	Nov. 15, 1892
DURANT, GEO. F.	Vice-Pres't of Bell Telephone Co. of Mo., 322 Pine St., St. Louis, Mo.	April 15, 1884
EDWARDS, JAMES P.	Graniteville, S. C.	April 19, 1892
EKSTROM, AXEL	Electrician, Thomson-Houston Electric Co., Lynn, Mass.	June 17, 1890
ELKY, HARRIS H.	Electrical Workshop Sup't. W. C. & S. W. Telephone Co., 88 Colston St., Bristol, Eng.	Jan. 7, 1890
ELMER, WILLIAM, JR.	Under-graduate in Electrical Engineering, Princeton University, Princeton, N. J.	Mar. 18, 1890
EMMET, HERMAN L. R.	Publisher and Printer, 36 Cortlandt St., New York City.	April 15, 1884

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
ENTZ, JUSTUS B.	Electrical Engineer, The Waddell-Entz Co., Bridgeport, Ct.	Jan. 7, 1890
ESSICK, SAMUEL V.	Electrician, The Essick Printing Tel. Co., 1 Broadway, New York City, and Vonkers, N. Y.	May 19, 1891
EVEREST, AUGUSTINE R.	Electrical Expert, Thomson Electric Welding Co., 89 State St., Boston, Mass.	May 19, 1891
FAY, THOMAS J.	39 King St., New York City.	June 26, 1891
FIELDING, FRANK E. [Life Member.]	Chemist and Assayer, Virginia City, Nev.	Sept. 6, 1887
FISCHER, GUSTAVE J.	Engineer for Tramway Construction, Public Works Department, Sydney, N. S. W.	Jan. 20, 1891
FISH, WALTER C.	Manager, Bernstein Electric Co., 620 Atlantic Ave., Boston, Mass.	June 26, 1891
FISHER, GEORGE E.	Secretary and General Manager, Commercial Electric Co., 55-57 Gratiot Ave., Detroit, Mich.	Sept. 27, 1892
FISKE, HENRY G.	Electrician, Croton Magnetic Iron Mines, 45 E. 22d St., New York City.	Nov. 12, 1889
FISKE, J. P. B.	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	June 17, 1890
FLACK, J. DAY	Ass't Electrician in charge of Tests, Edison Lamp Works, Harrison, N. J.	Dec. 6, 1887
FLATHER, JOHN J.	Professor of Mechanical Engineering, Purdue University, Lafayette, Ind.	April 19, 1892
FLESCHE, CHARLES	Electrical Engineer, Melbourne, Australia.	Sept. 27, 1892
FLOOD, J. F.	Supt. Steubenville Street Railway Co., Steubenville, O.	Mar. 18, 1890
FLOY, HENRY	168 North Ave., Allegheny, Pa.	May 17, 1892
FOOTE, ALLEN R.	Special Agent, Electrical Industries, U. S. Census, Takoma Park, D. C.	April 21, 1891
FOOTE, CHARLES W.	General Manager, The Nicholson Electric Hoist Co., 84 Champlain St., Cleveland, O.	Sept. 22, 1891
FOOTE, THOS. H.	153 John St., Bridgeport, Ct.	April 21, 1891
FORBES, FRANCIS	Lawyer, 137 Broadway, New York City.	Sept. 16, 1890
FORD, WM. S.	Assistant to Chief Engineer, The American Bell Telephone Co., Room 73, 125 Milk St., Boston, Mass.	June 7, 1892
FRANCISCO, M. J.	President and General Manager, Rutland Electric Light Co., Rutland, Vt.	June 17, 1890

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
FREEDMAN, WILLIAM H.	Honorary Fellow in Electrical Engineering, Columbia College, 120 West 125th St., New York City.	Mar. 18, 1890
FRENCH, E. L.	Stanley Laboratory Co., Pittsfield, Mass.	Dec. 16, 1890
FULLER, LEVI K.	Vice-President, Estey Organ Co., and Governor of Vermont, Brattleboro, Vt.	Mar. 5, 1889
GAINES, J. D.	Second Ass't. Superintendent, The Commercial Cable Co., Hazel Hill, N. S.	Oct. 21, 1890
GALE, HORACE B.	Consulting Electrical and Mechanical Engineer, 40 California St., San Francisco, Cal.	Nov. 15, 1892
GILES, WALTER A.	Engineer and Contractor, 416 Lewis Block, Pittsburg, Pa.	Nov. 1, 1887
GILLILAND, E. T.	Pelham Manor, N. Y.	April 15, 1884
GOLDMARK, CHAS. J.	473 Park Ave., New York City.	June 5, 1888
GORTON, CHARLES	Civil Engineer, Belmont, N. Y.	Nov. 12, 1889
GORDON, REGINALD	Assistant in Physics, Columbia College, Residence, 76 Park Ave., New York City.	Feb. 24, 1891
GRANER, ADOLF	Electrical Patent Agent, 529 North 35th St., Philadelphia, Pa.	Feb. 16, 1892
GRAY, W. N.	Electrical Engineer, 12 Chamber of Commerce, Cincinnati, O.	Oct. 1, 1889
GREENBERG, ADOLPH G.	Salesman, Washburn & Moen M'fg. Co., 16 Cliff St., New York City, 216 1/2 17th Street, Brooklyn, N. Y.	Mar. 17, 1891
GROSS, S. ROSS	Electrician, Tennessee Coal, Iron & R. R. Co., Ensley, Ala.	May 17, 1892
GROWER, GEORGE G.	Electrician and Chemist, Ansonia Brass and Copper Co., Ansonia, Conn.	Mar. 18, 1890
GRIFFIN, CAPT. EUGENE	Thomson-Houston Elec. Co., 295 Commonwealth Ave., Boston, Mass.	Feb. 7, 1890
GRUNOW, WILLIAM JR.	Expert Mechanician and Manufacturer of Special Machinery and Instruments, 204 and 206 East 43d St., New York City.	Jan. 19, 1892
GUTMANN, LUDWIG	Electrical Engineer, P. O. Box 118, Cleveland, O.	Sept. 14, 1888
HADLEY, WARREN B.	Supt. Wiring Dept., Edison Electric Illuminating Co., 431 Fifth Ave., New York City.	June 26, 1891
HALL, EDWIN H.	Assistant Professor of Physics, Harvard College, (Gorham St., Cambridge, Mass.	Sept. 3, 1889
HALL, JOHN L.	Manager, Western Union Telegraph Co., 300 Market St., Wilmington, Del.	Sept. 23, 1891

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
HALL, WILLIAM P.	President, The Hall Signal Co., 50 Broadway, New York City.	Sept. 16, 1890
HALSEY, WILLIAM B.	Inspector, Postal Telegraph-Cable Co., 94 Leonard St., New York City.	Mar. 18, 1890
HAMILTON, WILLIAM H.	Hamilton Electrical Works, 100 State St., Albany, N. Y.	Sept. 22, 1891
HANCOCK, L. M.	Supt. of Construction, Western Electric Co., 22 Thames St., New York City.	May 19, 1891
HANDLEY, ARTHUR	Electrical Engineer, Electrical En- gineering Co. of Ireland, Limited, 61 Dawson St., Dublin, Ireland.	Dec. 16, 1890
HARDING, H. McL.	Railway Dep't, Westinghouse Elec- tric & M'fg Co., 120 Broadway, New York City.	May 24, 1887
HARRINGTON, WALTER E.	Consulting Electric Railway Engi- neer, 2131 North 12th St., Phila- delphia, Pa.	Mar. 17, 1891
HART, FRANCIS R.	Supt. of Construction, Mass. Elec- trical Engineering Co., 4 P. O. Square, Boston, Mass.	April 21, 1891
HASKINS, CARYL D.	Manager Meter Dep't., General Elec- tric Co., 620 Atlantic Ave., Boston, Mass.	Mar. 18, 1890
HASSON, W. F. C.	Consulting Engineer, 104 Sutter St., San Francisco, Cal.	Mar. 18, 1890
HATZEL, J. C.	Electrical Engineer and Contractor, 114 Fifth Avenue, New York City.	Sept. 3, 1889
HEALY, LOUIS W.	The Wightman Electric Co., 1205 Marion St., Scranton, Pa.	June 26, 1891
HENSHAW, FREDERICK V.	Assistant Electrician, The "C. & C." Electric Motor Co., 402 Greenwich St., New York City.	Feb. 5, 1889
HERING, HERMANN S.	Associate in Electrical Engineering, Johns Hopkins University, Balti- more, Md.	April 21, 1891
HEWLETT, EDWARD M.	Electrical Engineer, Isolated Dept. Thomson-Houston Electric Co. 65 Columbia Heights, Brooklyn, N. Y.	May 19, 1891
HIGGINS, EUGENE	Assistant Electrical Engineer, with Frank B. Rae, 27 and 28 Cleland Building, 31st St., Detroit, Mich.	April 19, 1892
HILL, GEORGE	Chief Engineer and General Man- ager, Carrere and Hastings, 44 Broadway, New York City.	April 19, 1892
HOCHHAUSEN, WILLIAM	Electrician, The Excelsior Electric Co., 196 Willoughby St., Brook- lyn, N. Y.	April 15, 1884
HOFFMAN, SAMUEL V.	Post-graduate Student, Johns Hopkins University, Baltimore, Md.	Jan. 30, 1891

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
HOLCOMB, EUGENE R.	Engineering Dept., Edison Gen'l Elec. Co., Portland, Ore.	June 17, 1890
HOLMES, FRANKLIN S.	Electrical Engineer, with C. H. Davis, 120 Broadway, N. Y., 445a Macon St., Brooklyn, N. Y.	April 21, 1891
HOLT, MARMADUKE BURRELL	Mining and Electrical Engineer, The Colorado Smelting Co., Pueblo, Col.	April 15, 1890
HOOPES, ARTHUR	Edison Electric Illuminating Co., Westchester, Pa.	April 19, 1892
HOSFORD, HENRY H.	Electrical Engineer, 84 and 86 Champlain St., Cleveland, O.	Sept. 22, 1891
HOWSON, HUBERT	Patent Lawyer, 38 Park Row, New York City.	June 8, 1887
HUBRECHT, DR. H. F. R.	Director, Nederlandsche Bell Telephone Co., Amsterdam, Holland.	Oct. 4, 1887
HUFF, S. W.	General Manager, The Raleigh Street Railway Co., Raleigh, N. C.	Nov. 24, 1891
HUMPHREYS, C. J. R.	Manager, Lawrence Gas Co., Lawrence, Mass.	Sept. 6, 1887
HUNTING, FRED S.	Electrical Engineer, Fort Wayne Electric Co., 322 Washington St., Fort Wayne, Ind.	Nov. 15, 1892
IDELL, FRANK E.	Mechanical Engineer 41 Dey St., New York City.	July 12, 1887
ILHDER, JOHN D.	Electrical Engineer, with Osterheld & Eickemeyer, Manuf'rs of Dynamos and Motors, Yonkers, N. Y.	Oct. 2, 1888
INSULL, SAMUEL	President, Chicago Edison Co., 139 Adams St., Chicago, Ill.	Dec. 7, 1886
IVES, EDWARD B.	Lieutenant U. S. A., Electrical Engineer, 139th St. and Grand Boulevard, New York City.	April 2, 1889
IZARD, E. M.	Electrical Engineer, The Electrical Engineering Co., 320 Dearborn St., Chicago, Ill.	Mar. 5, 1889
JACKSON, J. P.	Assistant Professor of Electrical Engineering, Penn. State College, State College, Pa.	Sept. 27, 1892
JAMES, JOHN N.	Electrician, Naval Observatory, Washington, D. C.	Feb. 16, 1892
JEFFERY, D. HERBERT	Secretary and Treasurer, Crocker-Wheeler Electric Co., 430 West 14th St., New York City.	Oct. 25, 1892
JOHNSTON, A. LANGSTAFF	Civil and Consulting Engineer in the the General Construction of Electric Railways, 1105 E. Main St., Richmond Va.	April 21, 1891
JOHNSTON, W. J.	President, The W. J. Johnston Co., Ltd., Times Building, P. O. Box 3332, New York City.	April 15, 1884

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
JONES, PROFESSOR F. R.	University of Tennessee, Knoxville, Tenn.	May 20, 1890
JUDSON, WM. PIERSON,	U. S. Civil Engineer, Oswego, N. Y.	June 8, 1887
KEEN, WILLIAM M. B. <i>M.D.</i>	85 Varick Street, New York City.	Sept. 16, 1890
KELLOGG, JAMES W.	Assistant to District Engineer, General Electric Co., 140 E. 27th St., New York City.	June 26, 1891
KENNELLY, A. E.	(<i>Vice-President.</i>) Electrician, Ed- ison Laboratory, Orange, N. J.	May 1, 1888
KIMBALL, A. S.	Professor of Physics, Worcester Poly- technic Institute, Worcester, Mass.	Sept. 3, 1889
KINNEY, II. A.	[Address unknown.]	Mar. 18, 1890
KINSMAN, FRANK E.	Electrical Engineer, Plainfield, N. J.	Sept. 27, 1892
KREIDLER, W. A.	Editor and Publisher, <i>Western Elec- trician</i> , 6 Lakeside Building, Chi- cago, Ill.	Oct. 4, 1887
LAIN, DAVID E., <i>B. S.</i>	Electrical Engineer, Yonkers, N. Y.	Nov. 13, 1888
LAND, FRANK	69 Park St., Lynn, Mass.	Sept. 22, 1888
LAUDY, LOUIS H.	Assistant in Applied Chemistry, School of Mines, Columbia College, Residence, 239 West 52d St., New York City.	Feb. 24, 1891
LAW, MYRON D.	Electrical Engineer, Love Electric Traction Co., Chicago, Ill.	Feb. 7, 1888
LEDoux, A. R.	Chemical Expert, 9 Cliff St., New York City.	Dec. 7, 1886
LEE, JOHN C.	Chemist and Electrician, American Bell Telephone Co., Mountfort St., Longwood, Brookline, Mass.	Mar. 18, 1890
LEMP, HERMANN, JR.	Electrician, Thomson Electric Weld- ing Co., Lynn, Mass.	April 2, 1889
LENZ, CHARLES OTTO	2625 Wabash Ave., Chicago, Ill.	Mar. 15, 1892
LEVY, ARTHUR B.	Assistant Engineer, Arc Light Dep't, General Electric Co., 810 Lexing- ton Ave., New York City.	Jan. 20, 1891
LEWIS, HENRY FREDERICK	WILLIAM, 8 Meridian Road, Redland, Bristol, Eng.	Mar. 5, 1889
LIEDIG, GUSTAV A., JR.	Elec'l Testing Bureau, Johns Hop- kins University, Baltimore, Md.	Mar. 6, 1888
LITTLE, FRANKLIN P.	Manager, F. P. Little & Co., 141 East Seneca St., Buffalo, N. Y.	May 17, 1892
LLOYD, ROBERT MCA.	Electrician, 2 W. 36th St., New York City.	Oct. 21, 1890
LOGAN, CHARLES H.	[Address unknown.]	Nov. 18, 1890
LOOMIS, OSBORN P.	Electrician, Eureka Electric Co., 530 Nostrand Ave., Brooklyn, N. Y.	Sept. 16, 1890
LOVEJOY, J. R.	Electrical Engineer, Thomson-Hous- ton Electric Co., 620 Atlantic Ave., Boston, Mass.	April 21, 1891

ASSOCIATE MEMBERS.

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Name.	Address	Date of Election.
LOW, GEORGE P.	Electrical Inspector, Pacific Insurance Union, 307 Sansome St., San Francisco, Cal.	Jan. 17, 1893
LOWREY, GROSVENOR P.	Lawyer, 1 Broad St., Residence 121 Madison Ave., New York City.	Nov. 1, 1887
LOZIER, ROBERT T. E.	Electrical Expert, The General Electric Co., Broad Street, Box 3067, New York City.	May 20, 1890
LUFKIN, HARVEY L.	General Agent, Crocker-Wheeler Electric Co., 430 West 14th St., New York City.	June 17, 1890
LUNDELL, ROBERT	Electrical Engineer, Interior Conduit and Insulation Co., 44 Broad St., New York. Residence 1309 Bedford Ave., Brooklyn, N. Y.	Feb. 7, 1890
LUQUER, THATCHER T. P.	Asst. in Surveying and Practical Mining, and Student in Electrical Engineering, Columbia College, N. Y., and Bedford, N. Y.	June 26, 1891
MACFADDEN CARL K.	Electrical Engineer, Taylor, Goodhue & Ames, 827 Monadnock Block, Chicago, Ill.	Sept. 27, 1892
MACMULLAN, ROBERT HEATH.	Treasurer and General Manager, Brush Electric Lighting Co., Lafayette, Ind.	Sept. 22, 1891
MAC QUESTEN, W. D.	Electrical Engineer and Contractor, 15 Cortlandt St., New York City.	April 15, 1890
MADDEN, O. E.	136 Liberty St., New York City.	April 15, 1884
MAGEE, LOUIS J.	Electrical Engineer, in charge of European Office of Thomson-Houston International Electric Co., Michaelisbrücke 1, Hamburg, Gy.	April 2, 1889
MAGENIS, JAMES P.	Editor the <i>Adams Freeman</i> Adams, Mass.	Sept. 27, 1892
MALCOLM, PHILIP S.	Western Agent, Gibson Electric Co., Portland, Oregon.	Mar. 18, 1890
MANSFIELD, GEO. W.	Electrical Engineer, with Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	June 2, 1885
MARKS, LOUIS B.	Washington Carbon Co., Washington, Pa., Residence, 51 East 67th St., New York City.	May 20, 1890
MARPLE, LUCIUS E.	Associate Editor, the <i>Street Railway Gazette</i> , Phoenix Building, Chicago, Ill.	Sept. 22, 1891
MARTIN, A. J.	General Supt., West End Electric Co., 1310 N. 29th St., Philadelphia, Pa.	Mar. 15, 1892
MARTIN, F.	Electrical Engineer, Madison Square Garden Company, New York City.	Oct. 21, 1890
MARTIN, J.	Electrician, 16 Oak St., Newark, N. J.	Oct. 21, 1890

Name.	Address.	Date of Election.
MARTIN, T. COMMERFORD	(Past President.) Editor, <i>The Electrical Engineer</i> , 203 Broadway, New York City.	April 15, 1884
MASON, JAMES H.	Electrician and Supt., Mason Battery and Electrical Co., 120 Park Ave., Brooklyn, N. Y.	May 19, 1891
MAURO, PHILIP	Counsellor-at-Law in Patent Causes, (Pollock & Mauro), 620 F. St., Washington, D. C.	Dec. 21, 1892
MAVER, GEORGE M.	Mechanical Draughtsman, Electrical Department World's Columbian Exposition, Chicago, Ill.	Dec. 16, 1890
MCBRIDE, JAMES	Superintendent, N. Y. & Boston Dye Wood Co., 146 Kent St., Brooklyn, N. Y.	Sept. 27, 1892
MCCARTHY, LAWRENCE A.	Western Union Telegraph Co., New York City, 1053 Bedford Ave., Brooklyn, N. Y.	Jan. 19, 1892
MCELROY, JAMES F.	Mechanical Sup't, The Consolidated Car Heating Co., 131 Lake Ave., Albany, N. Y.	Nov. 15, 1892
McKIBBIN, GEORGE N.	Chemist and Electrician, Reed & McKibbin, Consulting Electrical Engineers and Contractors, 2 Wall St., New York City.	June 8, 1887
McKINSTRY, J. P.	185 Seneca St., Cleveland, O.	April 15, 1884
McKISSICK, A. F.	Professor of Electrical Engineering, The A. & M. College of Ala., Auburn, Ala.	Feb. 16, 1892
MCRÆ AUSTIN LEE	Professor of Physics, Missouri School of Mines, Rolla, Mo.	May 17, 1892
MERCER, ANDREW G.	Treasurer and Electrician, Waterloo Electric Co., Waterloo, N. Y.	Sept. 3, 1889
MERRITT, ERNEST	Assistant Professor in Physics, Cornell University, Ithaca, N. Y.	Sept. 16, 1890
MEYER, JULIUS	Consulting Engineer, North Amer- ican Co., Mills Building, New York City.	Oct. 25, 1892
MILLER, JOSEPH A.	Civil and Consulting Engineer, 25 Butler Exchange, Providence, R. I.	Dec. 9, 1884
MILLER, WM. C.	General Manager, Watervliet Turn- pike & R. R. Co., 3 South Hawk Street, Albany, N. Y.	Oct. 21, 1890
MINER, WILLARD M.	Electrician and Inventor, 89 East Second St., Plainfield, N. J.	July 12, 1887
MITCHELL, JOHN MURRAY	Lawyer, Box 3712, 45 Wall St., New York City.	June 2, 1885
MITCHELL, SIDNEY Z.	Manager, Oregon, Washington and Idaho Agency, General Electric Co., Fleischner Building, Portland, Or.	Nov. 12, 1889

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
MIX, EDGAR W.	Electrician, with Thomson-Houston International Electric Co., 7 Rue du Louvre, Paris, France.	Sept. 3, 1889
MONELL, JOSEPH T.	With F. B. Crocker, 236 W. 22d Street, New York City.	Oct. 27, 1891
MOORE, JOHN J.	425 E. Twenty-fourth St., New York City.	Nov. 12, 1889
MORDEY, WM. MORRIS	Electrician, Brush Electrical Engineering Co., 34 Montserrat Road, Putney, London, Eng.	Sept. 22, 1891
MORRISON, J. FRANK	15 South St., Baltimore, Md.	April 15, 1884
MORSS, EVERETT.	Electrician, Simplex Electric Co., 297 Beacon St., Boston, Mass.	Sept. 22, 1891
MORROW, JOHN THOMAS	Electrical Engineer, General Electric Co., Lynn, Mass.	Dec. 21, 1892
MORTON, HENRY, <i>PA. D.</i>	President of Stevens Institute of Technology, Hoboken, N. J.	May 24, 1887
MOSES, DR. OTTO A.	Electrician, 1037 Fifth Ave., New York City.	May 17, 1887
MOSS, GEO. W.	Station Manager, C. & S. A. Tel. Co., Coatzacoalcas, Mexico.	Jan. 7, 1890
MOSSCROP, WM. A. <i>M. E.</i>	Electrical Engineer, 128 Oliver St., Boston Mass.	May 7, 1889
MYERS, GEO. FRANCIS	Electrical and Mining Engineer, Penn Bldg. Pittsburg, Pa.	June 17, 1890
NESMITH, S. D.	[Address unknown.]	Sept. 16, 1890
NEWELL, ARTHUR J.	Electrical Engineer, R. T. Oakes & Co., 366 High St., Holyoke, Mass.	Mar. 18, 1890
NICHOLS, ARTHUR E.	Student in Electrical Engineering, Columbia College, 16 E. 35th St., New York City.	Mar. 18, 1890
NOLL, AUGUSTUS	New York Electric Equipment Co., 59 Duane St., New York City.	Sept. 27, 1892
NUNN, RICHARD J., <i>M. D.</i>	Physician, 119½ York St., Savannah Ga.	July 12, 1887
OCKERSHAUSEN, H. A.	Electrical Engineer, 65 Madison Ave., Jersey City, N. J.	Sept. 6, 1887
O'DEA, M.	Electrician, University of Notre Dame, Notre Dame, Ind.	June 8, 1887
OTTEN, DR. JAN D.	Engineer, Thomson-Houston International Electric Co., 1101 Mann Strasse 31v. Berlin, S. W. Germany.	Nov. 18, 1890
OWENS, R. B.	Professor of Electrical Engineering, University of Nebraska, Lincoln, Neb.	June 17, 1890
PAGE, A. D.	Assistant Manager, Edison General Electric Co. Lamp Works, Harrison, N. J.	Jan. 19, 1892
PALMER, G. W., JR.	[Address Unknown.]	April 15, 1890
PARCELLE, ALBERT L.	Electrician and Inventor, 157 Washington St., Boston, Mass.	Dec. 16, 1892

Name	Address	Date of Election.
PARKER, HERSCHEL C.	Assistant in Physics, Columbia College, 21 Fort Green Place, Brooklyn, N. Y.	April 19, 1892
PARKHURST, LIEUT. CHARLES D.	Inspector, Watervliet Arsenal, West Troy, and Troy House, Troy, N. Y.	Dec. 21, 1892
PARSKILL, HENRY V., JR.	31 East Twenty-first St., New York City.	Nov. 12, 1889
PAUL, CHAS. M.	Electrician, 172 Remsen St., Brooklyn, N. Y.	May 7, 1889
PEARSON, F. S.	Chief Engineer, West End Street Railway Co., 439 Albany Street, Boston, Mass.	Oct. 25, 1892
PECK, EDWARD F.	General Sup't Citizens Electric Illuminating Co., Cor. Rockwell Place and DeKalb Ave., Brooklyn, N. Y.	May 20, 1890
PECK, SAMUEL C.	Electrician, Thomson-Houston Electric Co., 620 Atlantic Ave, Boston, Mass.	Sept 6, 1887
PEIRCE, WM. H.	Assistant Manager, Baltimore Smelting and Rolling Co., Keyser B'ld'g, German and Calvert Sts., Baltimore, Md.	Sept. 7, 1888
PERKINS, FRANK C.	209 Central Ave., Dunkirk, N. Y.	Oct. 21, 1890
PEROT, L. KNOWLES	Consulting Electrical Engineer, 308 Walnut St., Philadelphia, Pa.	Mar. 15, 1892
PERRY, NELSON W., E. M.,	Assistant Editor, <i>Electrical World</i> , Times Building, New York City.	May 17, 1892
PHILLIPS, EUGENE F.	M'fr Insulated Electric Wire, Providence, R. I.	July 13, 1889
POOLE, CECIL P.	Contracting Electrical Engineer, 812 Church St. Lynchburg, Va.	Jan. 3, 1888
POOR, CHAS. LANE	Johns Hopkins University, Baltimore, Md.	Dec. 16, 1890
POPE, RALPH W.	Secretary to the American Institute of Electrical Engineers, 12 W. 31st St., Editor <i>Electric Power</i> , 136 Liberty St., New York City. Residence, 570 Cherry St., Elizabeth, N. J.	June 2, 1885
POWELL, WILLIAM H.	Manchester, Conn.	June 17, 1890
PUPIN, DR. MICHAEL I.	(Manager.) Instructor in Mathematical Physics, Columbia College, 68 W. 72d St., New York City.	Mar. 18, 1890
PUTNAM, H. ST. CLAIR	[Address unknown.]	Sept. 16, 1890
RANDALL, JOHN E.	Incandescent Lamp Dep't, Thomson-Houston Electric Co., 5 Vine St., Lynn, Mass.	May 7, 1889
RAY, WILLIAM D.	Electrician of Local Line of Northern Pacific R. R. Co., at Chicago, 308 Home Ave., Oak Park, Ill.	Sept. 27, 1892

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
READ, ROBERT H.	Patent Attorney, with <i>Electrical Review</i> , 13 Park Row New York City.	Jan. 19, 1892
REED, CHAS. J.	Electrician, 324 High St., Orange, N. J.	Mar. 5, 1889
REED, HENRY A.	Secretary and Manager, Bishop Gutta-Percha Co., 422 East Twenty-fifth St., New York City.	June 4, 1889
REID, THORBURN	Electrical Engineer, 24 Chase St., Lynn, Mass.	Oct. 21, 1890
REILLY, JOHN C.	General Sup't, N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
REINMANN, A. L.	Electrician, 45 Linden St., Brooklyn, N. Y.	June 8, 1887
REIST, H. G.	Electrical Engineer, Thomson-Houston Electric Co., 11 Baker St., Lynn, Mass.	June 17, 1890
RIKER, ANDREW L. [Life Member.]	Electrical Engineer, 737 Madison Ave., New York City.	Nov. 1, 1887
ROBINSON, ALMON,	Draughtsman, Expert in Methods of Gearing, P. O. Box, 943, Lewiston, Me.	Sept. 6, 1887
RODGERS, HOWARD S.	Electrical Engineer, Eddy Electric Mfg. Co., Windsor, Conn.	Sept. 27, 1892
RODMAN, SAMUEL, JR.	Lieut. 1st Artillery, U. S. A., 17 Quincy St., Chicago, Ill.	Sept. 16, 1890
ROEBLING, FERDINAND W.	Manufactures of Electrical Wires and Cables, Trenton, N. J.	June 8, 1887
ROESSLER, S. W.	Captain, U. S. A., U. S. Engineer Office, Memphis, Tenn.	Dec. 3, 1889
ROGERS, EDWARD H.	Patent Lawyer, firm of Pope and Rogers, 15 Wall St., New York City.	Sept. 22, 1891
ROSEBRUGH, THOMAS REEVE	Lecturer in Electrical Engineering, School of Practical Science, 107 Mutual St., Toronto, Ont.	June 26, 1891
ROSENBAUM, WM. A.	Electrical Patent Solicitor, Care of <i>The Electrical World</i> , Times Building, New York City.	Jan. 3, 1889
ROSENBERG, E. M.	The Yale and Towne Manufacturing Co., Stamford, Conn. Residence, 784 Lexington Ave., New York City.	Oct. 21, 1890
ROSS, ROBERT A.	Engineer in charge of Engineering Dept., Edison General Electric Co., Petersburg, Ont.	Sept. 27, 1892
ROYCE, FRED W.	Electrician and Patent Solicitor, 1408 Pennsylvania Ave., Washington D. C.	April 15, 1884

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
RUTHERFORD, W. M.	Toronto Construction and Electrical Supply Co., 63 Front Street, W. Toronto, Can.	Sept. 22, 1891
RYAN, HARRIS J.	Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.	Oct. 4, 1887
SACHS, JOSEPH	Electrician, The American Engineering Co., 109 World Building. Residence, 1839 Lexington Ave., New York City.	Mar. 15, 1892
SANBORN, FRANCIS N.	Manhattan Electric Lighting Co., 13 Spencer Place, Brooklyn, N. Y.	Nov. 24, 1891
SARGENT, W. D.	General Manager, N. Y. & N. J. Tel. Co., 16 Smith St., Brooklyn, N. Y.	April 15, 1884
SAWYER, FREDERICK J.	381 Boylston St., Boston, Mass.	June 8, 1887
SAXELBY, FREDERICK	Electrical Engineer, 288 Summer Ave., Newark, N. J.	June 5, 1888
SCHLOSSER, FRED. G.	Superintendent of Electric Dept., Laclede Gas Light Co., 1038 Leffingwell Ave., St. Louis, Mo.	Sept. 22, 1891
SCHMID, ALBERT	Superintendent, Westinghouse Electric & Mfg. Co., Pittsburg, Pa.	Oct. 21 1890
SCHMIDT, FREDERICK	Managing Director, The Schmidt-Douglas Electric Co., L'td., 31 Blenheim Rd., Bradford, England.	Jan. 3, 1888
SCHMIDT, GIACOMO	Ass't General Manager, Richmond Light, Heat and Power Co., New Brighton, N. Y.	April 21, 1891
SCHREITER, HEINR	Editor, <i>Der Techniker</i> , 11 Chambers St., New York City.	Jan. 17, 1893
SEARING, LEWIS	Shepard & Searing, Mechanical and Electrical Engineers, 513 and 514 Mining Exchange, Denver, Colorado.	April 3, 1888
SEE, A. B.	A. B. See Manufacturing Co., 1235 Bedford Ave., Brooklyn, N. Y.	Jan. 17, 1893
SEELY, J. A.	General Manager, Complete Construction Co., 10 Cortlandt St., New York City.	April 15, 1884
SERRELL, LEMUEL WM.	Mechanical and Electrical Engineer, 10 Wall St., New York City.	Nov. 1, 1887
SHAIN, CHARLES D.	136 Liberty St., New York City.	June 7, 1892
SHAW, EDWIN C.	General Superintendent, Thomson-Houston E. L. and P. Co., 40 Court St., Buffalo, N. Y.	May 17, 1892
SHAW, GEORGE B.	General Manager, National Electric Mfg. Co., Eau Claire, Wis.	April 15, 1890
SHEBLE, FRANKLIN	Electrical Engineer, Thomson-Houston Electric Co., Lynn, Mass.	Oct. 21, 1890
SHEEHY, ROBERT J.	Electrical Engineer, Equitable Mfg. and Electric Co., 24 West St. and 101 W. 76th St., New York City.	April 21, 1891

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
SHEPARDSON, GEORGE D.	Dep't. of Electrical Engineering, University of Minnesota, Minne- apolis, Minn.	April 21, 1891
SINCLAIR, H. A.	Electrical Engineer. The Tucker Electric Co., 950 Bedford Ave., Brooklyn, N. Y.	June 17, 1890
SISE, CHARLES F.	Vice-President and Managing Direc- tor, Bell Telephone Co., of Canada, and Canadian Telephone Co., Ltd., P. O. Box 1918, Montreal, Canada.	June 8, 1887
SMITH, FRANK STUART	Supt. of Carbon Dept., Westing- house Electric & Mfg. Co., Pitts- burg, Pa.	Sept. 27, 1892
SMITH, FREDERICK H.	Civil Engineer. 227 East German St., Baltimore, Md.	Nov. 12, 1889
SMITH, HAROLD BABBITT.	Barre, Mass.	Nov. 24, 1891
SMITH, J. ELLIOT	Superintendent Fire Alarm Tele- graph, 122 West 73rd St., New York City.	April 15, 1884
SMITH, OBERLIN	President and Mechanical Engineer, Ferracute Machine Co., Lochwood, Bridgeton, N. J.	May 19, 1891
SMITH, T. JARRARD	Manager Electrical Dep't., The E. S. Greeley & Co., 5 and 7 Dey St., New York City.	April 19, 1892
SOUZA, CARLOS MONTÊIRO e	Rio de Janeiro, Brazil.	Sept. 6, 1887
SPAULDING, HOLLON C.	P. O. Box 454, Exeter, N. H.	April 21, 1891
SPERRY, ELMER A.	Electrical Engineer, Sperry Electric Mining Machine Co., 39th St. and Stewart Ave., Chicago, Ill.	April 19, 1892
SPICER, CHAS. W. W.	136 W. 21st Street, New York City.	Nov. 12, 1889
SPIKE, CLARENCE J.	Halifax, N. S.	Mar. 18, 1890
SPRAGUE, FRANK J.	(President.) Electrical Engineer and Inventor, 182 West End Ave., Firm of Sprague, Duncan & Hutchinson, 15 Wall St., New York City.	May 24, 1887
SPRUSON, WILFRED J.	Member of the firm of Hepburn & Spruson, Consulting Engineers and Electricians, 169 King St., Sydney, Australia.	Dec. 16, 1890
SQUIER, GEORGE O.	Lieut. U. S. A., Student of Physics, Box 243, Johns Hopkins Univer- sity, Baltimore, Md.	May 19, 1891
STADELMAN, WM. A.	Vice-Prest. and Chief Engineer, Equit- able Engineering and Construction Co., Drexel Building, Philadelphia, Pa.	Feb. 7, 1890
STAHL, TH.	Creusot Works, Creusot, France.	Nov. 15, 1892
STANLEY, WILLIAM, JR.	Electrician, Pittsfield, Mass.	Dec. 6, 1887

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
STEARNS, CHARLES K.	Sup't of Construction, N. W. Thomson-Houston Electric Co., 403 Sibley St., St. Paul, Minn.	Aug. 6, 1889
STOCKBRIDGE, GEO. H.	Patent Attorney, and Editor <i>Electric Power</i> , 136 Liberty St., New York City.	May 24, 1887
STOCKLY, GEO. W.	President, Brush Electric Co., Cleveland, O. Lakewood, N. J.	April 15, 1884
STONE, CHARLES A.	Manager with E. S. Webster, Mass. Electrical Engineering Co., 4 P. O. Square Boston, Mass.	May 19, 1891
STRONG, FREDERICK G.	Lowe Gas and Electric Co., Colorado Springs, Colo.	Oct. 27, 1891
STUMP, CLARENCE E.	Vice-President and Business Manager, Street Railway Publishing Co., World Building, New York.	May 17, 1887
SULLIVAN, M. C.	Electrical Engineer, 136 Liberty St., New York City.	Dec. 16, 1890
SUMMERS, LELAND L.	Electrician, Postal Telegraph Co., 211 Phoenix Building Chicago, Ill.	Feb. 16, 1892
SWEET, HENRY N.	Chief of Patent Bureau, Thomson Electric Welding Co., 89 State St., Boston, Mass.	May 20, 1890
TABER, ROBERT B.	Gas Engineer, Special Agent Thomson-Houston Electric Co., 620 Atlantic Ave., Boston, Mass.	Sept. 16, 1890
TAPLEY, WALTER H.	Electrician in Government Printing Office, Care of Public Printer, Washington, D. C.	Oct. 25, 1892
TAYLOR, CHARLES	Metallurgist, U. S. Assay Office, 30 Wall St., New York City.	Nov. 1, 1887
TEMPLE, WILLIAM CHASE	Mechanical and Electrical Engineer, Lewis Block, P. O. Box 800 Pittsburgh, Pa.	May 3, 1887
TESLA, NIKOLA	(Vice-President.) Electrical Engineer and Inventor, The Gerlach, 55 West 27th St., New York City.	June 5, 1888
THOMPSON, WILLIAM GEO. MACNEILL	Resident Engineer, Sault Ste. Marie Canal, St. Catherines, Ont.	July 12, 1887
TISCHENDOERFER, FRED W.	Electrical Engineer, 116 Buena Vista Ave., Yonkers, N. Y.	April 19, 1892
TOBEY, WILLIAM BOARDMAN	The Stanley Laboratory Co., Pittsfield, Mass.	Sept. 16, 1890
TOWNSEND, HENRY C.	Attorney and Expert in Electrical Cases, 5 Beckman St., New York City.	July 10, 1888
TREGONING, JOHN	32 Belmont Ave., Providence, R. I.	April 2, 1889
TROTT, A. H. HARDY [Life Member.]	Electrical Expert, with Thomson-Houston Electric Co., Lynn, Mass.	Jan. 20, 1891
TUTTLE, GEORGE W.	Storekeeper, Sawyer-Man Electric Co., 510 West 23d St., New York City.	Mar. 17, 1891

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
UEBELACKER, CHAS. F.	Brush Electric Co., and 1299 Euclid Ave., Cleveland Ohio.	Feb. 7, 1890
UEHLING, T. A.	179 Sawtell Ave., Cleveland, O.	May 19, 1891
UHLENHAUT, FRITZ, JR.	139 North 15th St., Philadelphia, Pa.	May 7, 1889
VAIL, THEO. N.	18 Cortlandt St., New York City.	April 15, 1884
VAN BRUNT, WALTER	Manager, Duluth Telephone Co., Duluth, Minn.	Sept. 6, 1887
VAN BUREN, GURDON C.	Electrician, 5 Wilson Street, Albany, N. Y.	Oct. 25, 1892
VANCE, A. ST. CLAIR	General Superintendent, The H. Ward Leonard & Co., 136 Liberty Street, New York City.	April 2, 1889
VANDERGRIFF, JAMES A.	Assistant Supt. and Electrician, Sawyer-Man Electric Co., 534 W. 23d St., New York City.	Nov. 24, 1891
VAN TRUMP, C. REGINALD	Wilmington City Electric Co., Wilmington, Del.	Feb. 5, 1889
VAN VALKENBURGH, F. S.	906 Second St., Seattle, Wash.	June 5, 1886
VAN VLECK, FRANK	Executive Engineer, Pacific Railway Co., Los Angeles, Cal.	Nov. 16, 1886
VAN WYCK, PHILIP V. R., JR.	Room 13, 18 Cortlandt St., 127 W. 58th St., New York City.	April 21, 1891
VARLEY, RICHARD, JR.	Electrician, Okonite Insulated Wire Co., Passaic, N. J.	Mar. 18, 1890
VERLEY, HORACE S. L.	With Dr. Wm. E. Geyer, as Laboratory Assistant, Stevens Institute, Hoboken, N. J.	May 17, 1892
WACKER, GEORGE G.	Electric Organs, 3644 Third Ave., New York City.	Sept. 6, 1887
WALLACE, GEO. S.	Telegraph Office Manager, Chesapeake & Ohio Ry. Co., Box 214, Clifton Forge, Va.	Oct. 25, 1892
WALLACE, WILLIAM	Wire Manufacturer, Ansonia, Conn.	April 15, 1884
WALTER, HENRY E.	3 Princes Mansions, Victoria St., London, Eng.	April 2, 1889
WARDELL, GEORGE P.	19 Cedar St., Newark, N. J.	Nov. 12, 1889
WARING, RICHARD S.	Standard Underground Cable Co., 61 Westinghouse Bldg., Pittsburg, Pa.	April 15, 1884
WARING, JOHN	Consulting Electrician, The Perkins Electric Lamp Co., Manchester, Conn.	Dec. 16, 1890
WASON, CHAS. W.	Electrical Engineer, East Cleveland R. R. Co., 1154 Euclid Ave., Cleveland, O.	May 19, 1891
WATERHOUSE, FRANK G.	Room 6, No. 302 Asylum St., Hartford, Conn.	Sept. 6 1887

ASSOCIATE MEMBERS.

Name.	Address.	Date of Election.
WATERS, EDWARD G.	Electrical Engineer, Thomson-Houston Electric Light Co., German National Bank Building, Pittsburgh, Pa.	Mar. 18, 1896
WATSON, ROBERT	The Elektron M'fg. Co., 89 Liberty St., New York City.	Oct. 21, 1890
WATTS, H. FRANKLIN.	Electrical Engineer, 10 Cortlandt St., New York City.	May 20, 1890
WEAVER, NORMAN R.	Supt. of Repair Department, General Electric Co., 173-5 Adams' St., Chicago, Ill.	Oct. 25, 1892
WEBSTER, DR. ARTHUR G.	Docent in Physics, Clark University, Worcester, Mass.	Jan. 19, 1892
WEBSTER, EDWIN S.	Mass. Electric Engineering Co., 4 P. O. Square, Boston, Mass.	April 21, 1891
WESSELS, EDWARD J.	New York Agent, The Short Electric Railway Co., 44 Broad St., New York City.	Mar. 15, 1892
WELLES, FRANCIS R.	Manufacturer, Bell Telephone Manufacturing Co., Antwerp, Belgium	Sept. 6, 1887
WHITE, GEO. MONTAGU	Agent for West Indies, Thomson-Houston International Electric Co., Kingston, Jamaica, W. I.	Sept. 22, 1891
WHITE, H. C.	Manager, Phoenix Iron Works Co., 15 Cortlandt St., New York City.	April 15, 1884
WHITE, J. G.	J. G. White & Co., Electrical Engineers and Contractors, 29 Broadway New York City.	April 2, 1889
WHITE, WILL F.	Electrical Engineer, Sec'y and Treas. Western Engineering Co., 415 So. 15th St., Omaha, Neb.	Feb. 7, 1890
WHITMORE, W. G.	Electrical Engineer, General Electric Co., Edison Building, Box 3067, New York City.	Mar. 18, 1890
WHITNEY, HENRY M. [Life Member.]	President, West End Street Railway Co., 81 Milk St., Boston, Mass.	July 12, 1887
WIGHTMAN, MERLE J.	Vice-President and Electrician, The Wightman Elec. Mfg. Co., 4 Commonwealth Bldg., Scranton, Pa.	Mar. 5, 1889
WILEY, WM. H.	Scientific Expert, 53 East 10th St., New York City.	Feb. 7, 1888
WILLIAMS, ARTHUR S.	53 Devonshire St., Boston, Mass.	Nov. 24, 1891
WILLIAMS, CHARLES, JR.	Electrician, 100 Sudbury St., Boston, Mass.	April 15, 1884
WILLIAMS, JAMES B. M. D.	44 Broadway, and 120 West 57th St., New York City.	Sept. 7, 1888
WILLYOUNG, ELMER G.	Electrician, James W. Queen & Co., 924 Chestnut Street, Philadelphia, and Ardmore, Pa.	Nov. 24, 1891
WINKLER, CHARLES F.	Electrician, Troy Electric Dynamo Co., 4 Park Ave., Troy, N. Y.	Sept. 3, 1889

ASSOCIATE MEMBERS.

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Name.	Address.	Date of Election.
WINSLOW, I. E.	Manager, Roundhay Electric Tramway, 146 Roundhay Road, Leeds, Eng. Address, 457 Produce Exchange, New York City.	Nov. 12, 1889
WINTRINGHAM, J. P.	Theorist, 36 Pine St., New York City.	May 7, 1889
WIRT, CHARLES.	(Manager.) Electrical Engineer of the Electrical Supply Co., 102-104 Michigan Ave., Chicago, Ill.	Sept. 8, 1888
WIRT, HERBERT C.	Electrician, Marine Dept. Thomson-Houston Electric Co., 12 Millmont St., Roxbury, Mass.	June 26, 1891
WOLVERTON, B. C.	Electrician, N. Y. & Pa. Telephone & Telegraph Co., Elmira, N. Y.	Mar. 18, 1890
WOOD, E. J.	Consulting Engineer and Contractor, 243 Broadway, New York City.	July 12, 1887
WOODRUFF, H. O.	Manager, Sioux City Electric Co., Sioux City, Iowa.	Oct. 2, 1888
WOODWARD, FRANCKE L.	Student in Electricity, 13 Kirkland Place, Cambridge, Mass.	June 26, 1891
WOOLF, ALBERT E.	Electrician and Inventor, Woolf Electrical Co., 110 Pearl St. and 864 Lexington Ave., New York City.	Sept. 16, 1890
WRIGHT, JOHN D.	[Address Unknown.]	Oct. 21, 1890
ZALINSKI, EDMUND L.	Captain of Artillery, U. S. A., Care of War Dept., Washington, D. C.	May 17, 1887

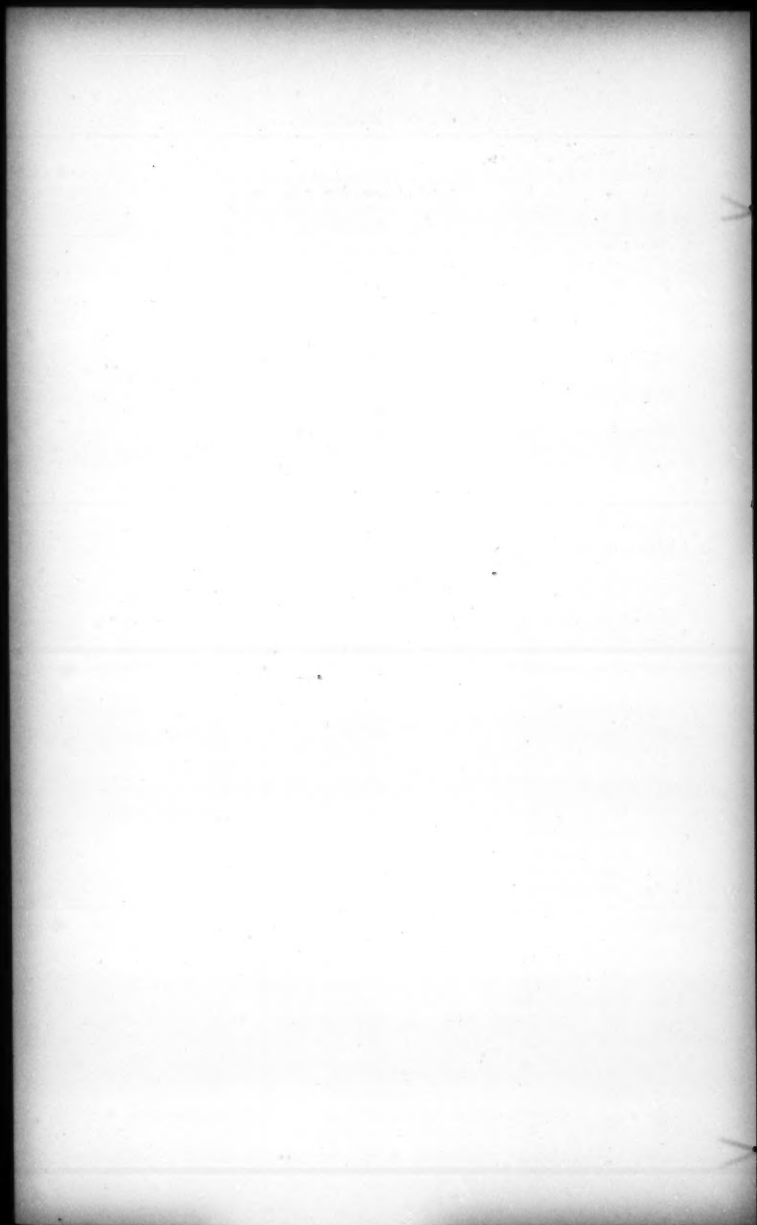
Associate Members, - - - 447.

OFFICIAL STENOGRAPHER.

RYAN, RICHARD W., 300 Mulberry St., New York City.

SUMMARY.

Honorary Members.	- - - - -	4
Members, - - -	- - - - -	195
Associate Members.	- - - - -	447
Total	- - - - -	646



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INDUCTANCE, AND ITS PROPOSED UNIT, THE "HENRY." (Illustrated.) By A. E. Kennelly. THE IMPROVED TRANSFORMER. (Illustrated.) By Emilie Berlin. No. 1, January, 1891. INDUCTION, AND ITS PROPOSED UNIT, THE "HENRY." REPORT OF COMMITTEE ON VALUATION OF THE HENRY. Joint Discussion. No. 2, February, 1891. REPORT OF HIGH SPEED ELECTRIC RAILWAY WORK. (Illustrated.) By O. T. Crosby. THE INVENTIONS OF THOMAS DAYTON. (Illustrated.) By Franklin L. Pope. No. 3, March, 1891. INDUCTIVE DISTURBANCE IN TELEPHONE CIRCUITS. (Illustrated.) By J. J. Carty. No. 4, April, 1891. ELECTRICITY IN THE PRODUCTION OF ALUMINUM. (Illustrated.) By Alexander S. Brown. SOME POSSIBLE MODIFICATIONS IN THE METHODS OF PROTECTING BUILDINGS FROM LIGHTNING. By N. D. C. Hodges. No. 5, May 1891. REPORTS OF COUNCIL AND TREASURER. OFFICERS ELECTED. THE PERFECTION OF STATIONARY ELECTRIC MOTORS. (Illustrated.) By Francis B. Crocker. A PHOTOGRAPHIC STUDY OF THE ELECTRIC ARC. (Illustrated.) By Edward L. Nichols. A NEW GRAPHICAL METHOD OF CALCULATING LEADS FOR WIRING. (Illustrated.) By Carl Herting. A THERMO-ELECTRIC METHOD OF STUDYING STEAM CYLINDER CONDENSATION IN STEAM ENGINES. (Illustrated.) By Edwin H. Hall. THE PRACTICAL ASPECTS OF ELECTRIC WELDING. By Frederic A. C. Pettie. EXPERIMENTS WITH ALTERNATE CURRENTS OF VERY-HIGH FREQUENCY. (Illustrated.) By Nikola Tesla. Nos. 6 and 7, June and July, 1891. AN ALTERNATE CURRENT POTENTIOMETER. (Illustrated.) By Geo. S. Moler. CONSIDERATIONS WHICH SHOULD GOVERN THE SELECTION OF A RAPID TRANSIT SYSTEM. By F. J. Sprague. ELECTRIC METERS. By Geo. W. Walker. A STUDY OF AN OPEN COIL ARC DYNAMO. (Illustrated.) By Milton E. Thompson. THE FUTURE OF THE ALUMINUM PROBLEM FROM THE CHEMICAL STANDPOINT. By Wm. H. Wahl. SMALL "ALUMINUM" OR "ALUM." By Oberlin Smith. NOTES ON ELECTRICITY IN MINING WORK. (Illustrated.) By Sydney F. Walker. Nos. 8 and 9, August and September, 1891. ON THE RELATION OF THE AIR GAP AND THE SHAPE OF THE POLES TO THE PERFORMANCE OF DYNAMO ELECTRIC MACHINERY. (Illustrated.) By Harris J. Ryan. No. 10, October, 1891. MAGNETIC RESISTANCE. (Illustrated.) By A. E. Kennelly. REPORT OF COMMITTEE ON UNITS AND STANDARDS. REPORT OF DELEGATION TO FRANKFURT INTERNATIONAL ELECTRICAL CONGRESS. No. 11, November, 1891. NOTES ON THE FRANKFURT ELECTRICAL EXHIBITION. By Carl Herting. ON POLYPHASE GENERATORS. (Illustrated.) By M. I. Pupin. CATALOGUE OF MEMBERS AND PUBLICATIONS, December, 1891.

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